Vol IX, Part IV Quarterly OCTOBER, 1914

THE AGRICULTURAL JOURNAL OF INDIA

AGRICULTURAL RESEARCH INSTITUTE, PUSA

PUBLISHED FOR
THE IMPERIAL DEPARTMENT OF AGRICULTURE IN INDIA
BY
THACKER, SPINK & CO., CALCUTTA
W. THACKER & CO., 2, Creed Lane, LONDON

Agents for the Sale of Government Publications

IN THE UNITED KINGDOM.

Constable & Co., 10, Orange Street, Leicester Square, London, W.C.

Kegan Paul, Trench Trübner & Co., 68-74, Carter Lane, E.C.

Bernard Quaritch, 11, Grafton Street, New Bond Street, London, W.

P. S. King & Son, 2 & 4, Great Smith Street, Westminster, London, S.W.

H. S. King & Co., 65, Cornhill, E.C., and 9, Pall Mall, London, W.

Grindlay & Co., 54, Parliament Street, London, S.W.

T. Fisher Unwin, 1, Adelphi [illegible], London, W.C.

W. Thacker & Co., 2, Creed Lane, [illegible] E.C.

Luzac & Co., 46, Great Russell Street, London, W.C.

B. H. Blackwell, 50 & 51, Broad Street, Oxford.

Deighton, Bell & Co., Cambridge.

Oliver & Boyd, Tweeddale Court, Edinburgh.

E. Ponsonby Ltd., 116, Grafton Street, Dublin.

ON THE CONTINENT.

Ernest Leroux, 28, Rue Bonaparte, Paris.

Martinus Nijhoff, The Hague, Holland.

IN INDIA AND CEYLON.

Thacker, Spink & Co., Calcutta and Simla.

Newman & Co., Calcutta.

R. Cambray & Co., Calcutta.

S. K. Lahiri & Co., Calcutta.

B. Bannerjee & Co., Calcutta.

The Calcutta School Book and Useful Literature Society, 309, Bow Bazar Street, Calcutta.

Butterworth & Co. (India), Limited, Calcutta.

The Weldon Library, 18-5, Chowringhee Road, Calcutta.

Rai M. C. Sircar Bahadur & Sons, 75-1-1, Harrison Road, Calcutta.

Higginbotham & Co., Madras.

V. Kalyanarama Iyer & Co., Madras.

G. A. Natesan & Co., Madras.

S. Murthy & Co., Madras.

Thompson & Co., Madras.

Temple & Co., Madras.

Combridge & Co., Madras.

P. R. Rama Iyer & Co., Madras.

Thacker & Co., Ld., Bombay.

A. J. Combridge & Co., Bombay.

D. B. Taraporevala Sons & Co., Bombay.

Radhabai Atmaram Sagoon, Bombay.

Sunder Pandurang, Bombay.

Gopal Narayan & Co., Bombay.

Ram Chandra Govind & Son, Kalbadevi, Bombay.

N. B. Mathur, Superintendent, Nazir Kanun Hind Press, Allahabad.

A. Chand & Co., Punjab.

Rai Sahib M. Gulab Singh & Sons, Mufid-i-Am Press, Lahore, and Calcutta.

Superintendent, American Baptist Mission Press, Rangoon.

S. C. Talukdar, Proprietor, Students and Company, Cooch Behar.

A. M. & J. Ferguson, Colombo, Ceylon.

CONTENTS

METHODS OF ECONOMISING WATER USED IN IRRIGATION IN AMERICA.

BY

M. NETHERSOLE, C.S.I.,

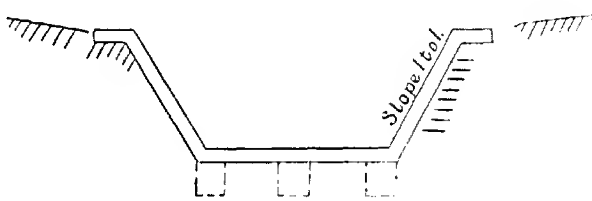
Inspector-General of Irrigation in India.

PUBLIC interest at the National Irrigation Congress, at Pueblo, centred in the partition of supplies as between neighbouring States, and its control by the Federal Government; with but few exceptions the papers read, and the ensuing discussions, dealt with these political questions, rather than with the technique and practice of irrigation.

In the exhibition there was a good show of the products of local irrigation, and of pictorial advertisement, calculated to attract settlers to the irrigated tracts of the Western States; and the show of agricultural implements was fair. But irrigation plant was poorly represented; there were four exhibits of gasoline and electric pumps suitable for small installations; a mechanical lift of the Persian wheel type, and one or two samples of patent cement piping. There were no demonstrations of economical methods of distribution. Thus, considered either as a field of technical discussion, or as an exhibition of the practical points, the Congress was disappointing though through the courtesy of the Board of Control, and more especially of Dr. Gray, the Foreign Secretary to the Board, the writer was put in touch with several of the leading men, official and private, who were interested in irrigation in all parts of the States, to whom he is indebted for the information contained in this memorandum. It is to be regretted that time did not permit of accepting the many invitations offered for inspecting the different systems.

Lining of Main and Distributing Channels to prevent seepage.—There is a marked advance in America as compared with Indian practice in the lining of channels to prevent losses of percolation. Cement concrete is the lining most generally adopted as in the typical section sketched in Fig. 1.

Fig. 1



The thickness varies from a 1″ plaster skin applied to small water-courses carrying 1 cusec and upwards, to 3″ for a channel carrying about 10 cusecs and upwards, to a 6″ lining for a channel of 700 cusec capacity which is the largest to which such a lining has so far been applied. In the larger sections the bed is fortified by small dwarf walls shown in dotted lines in the sketch.

Other methods employed are timber flumes built of scantlings or planks either of circular section, strapped with iron hoops, or rectangular—these are however generally used only along hill-sides and in difficult positions; the tendency being to use the more durable cement-concrete whenever it is possible to do so.

As an example of this wholesale lining of channels, reference may be made to the Beaver Creek Irrigation scheme. The scheme was started two years ago by a private company who bought the tract, together with the water-rights, from the old settlers, who were unable to fully utilize the supply owing to the difficulty of getting the water on to the land. The price paid was from \$4 to \$5 per acre. The creek supply is estimated to average 40 cusecs with a minimum of 18 cusecs in the summer months; it was 25 cusecs at the time of inspection. In order to help out the minimum supply two storage reservoirs are included in the scheme—one to contain 3,000 acre feet is very nearly completed, the other to contain 4,000 acre feet is not

yet commenced. The whole of the distributary system is lined, with the exception of one length which is in such good clay that lining was considered unnecessary. The supply channel is partly of circular wooden fluming, 42″ in diameter, and partly of cement-concrete lining. The distributaries south of the main are all of cement piping varying from 2′ 0″ to 8″ in diameter, laid from 2′ 0″ to 3′ 0″ below ground surface. Water is delivered to the land-owners by measurement over weir crests at surface boxes. One such box is provided at or near the corners of each 40 acre plot; so that each 10 acre plot, which is the minimum holding permitted, has easy access to its supply.

The first impression, on inspecting this scheme, was one of surprise that it should be capable of giving an adequate return on the expense of engineering it on the scale described. The explanation lies in the enormous crop values realised on irrigated lands in America. At the Congress it was stated that as much as from $1,000 to $1,500 = Rs. 3,000 to Rs. 4,500 was the gross value per acre of a good fruit crop from irrigated orchards, and even as much as $4,000 = Rs. 12,000 in exceptional cases in the orange orchards in California; values which are impossible in India. The Manager of the Beaver Co., who is an orchard farmer of long experience, stated that he regards $1,700 as a safe estimate of average yield for a well stocked orchard in full bearing. Hence it is not surprising to find that the land is selling readily at from $200 to $300 per acre as soon as water is available; and of the 4,500 acres which is in command of the present scheme with its single reservoir, the company has sold over 3,500 acres, the greater part of which was already stocked with young fruit trees and vines and cropped with lucerne and maize.

The supply is adjusted, on the indents of each owner, by Ditch-riders who report the same by daily cards to the head office in Penrose. As soon as the water supply is secured to each section the company sell the land with the water-right to 1·5 acre feet per year delivered at the surface boxes, no further water rates are charged except for upkeep and regulation which remains in the control of the company; this cost is posted daily, in ledgers which are at all

times open to the inspection of the land-owners, and is periodically distributed *pro rata* on the whole acreage. The cost of upkeep for the present year is estimated at $1·50 per acre, construction being still in progress; it is expected to rise to about $2 per acre when the scheme is complete, and the sale contracts preclude its ever exceeding $3 per acre, the company accepting all liabilities above this limit. There is a Resident General Manager in charge who undertakes the clearance and stocking of the land for non-resident purchasers at cost price: thus the whole system is self-contained and co-operative.

The land-owners are already commencing to line the water-courses leading from the surface boxes with cement, and the Engineer in charge was arranging with one of the Oil Companies for a supply of heavy oil at wholesale rate for treatment of the smaller channels. He hoped to be able to supply it to the land-owners at about 6 cents (3 annas) per gallon. Experiments on the various linings suitable for small water-courses were carried out by the Bureau of Irrigation Investigation in 1907 with result as follows:—

Nature of lining	Average percolation in inches per hour per 10 days including all evaporation.	Ratio of Efficiency.
Earth Channel no lining	0·355	1·00
" " light oil ..	0·329	1·08
" " heavy oil 2½ gallons per yard	0·239	1·37
Clay puddle ..	0·185	1·78
Earth Channel heavy oil 3½ gallons per yard	0·176	2·02
Cement mortar 1 inch	0·121	2·73
" concrete 3 inches ..	0·046	7·17

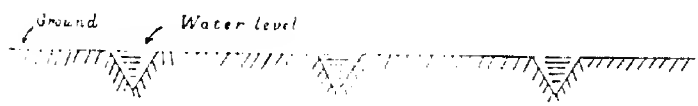
Considerable progress is being made in all parts of the country in the lining of small water-courses, more especially where crop values are high and the water scarce. This is generally done in all pumping schemes.

Methods of field distribution. Surface flooding. American methods of applying the water to the fields differ considerably from those practised in India. The general use of machinery for cultivation and harvesting renders it inconvenient to sub-divide

the fields into small compartments by means of ridges: hence in America for surface flooding it is the practice to take a great deal of trouble in systematic levelling of the fields so that large areas may be flooded equally without undue waste or damage to the crop in the lower levels. This point was strongly insisted on, as essential to successful and economical irrigation by this method, by more than one practical farmer. It follows that water is generally handled in larger volumes than is the case in India.

Furrow system of irrigation. Except for rice and small grain crops the tendency in America is to irrigate by the furrow system, explained in the sketch:

Fig 2



the water being run into a series of furrows by means of a transverse feeder crossing them at a high level. For a field longer than say 330 feet a second transverse feeder is introduced. This method to be successful also requires very careful grading of the field in the direction it is intended to run the furrows. The chief advantage claimed for this method is a diminution of evaporation losses. Experiments conducted by the Irrigation Investigation branch of the Agricultural Department give the following comparative evaporation losses for the same soil for the period June 20th to October 24th:

	Acre feet.
By surface flooding	0·62
" furrows 3 inches deep	0·55
" " 12 inches deep	0·41

This practice appears to have originated in the irrigation of fruit orchards, large furrows being run down each side of the tree rows; but it has quickly extended to any crop which is planted in rows sufficiently far apart to admit of the furrows (made

of course by a furrowing machine of which there are several patterns) being run between them without injury to the crop. One farmer near Denver said he was intending next season to apply it experimentally to wheat, spacing the rows 10″ apart for the purpose.

Retention of moisture in the soil.—American practice is extending largely in the direction of "cultivation" after each watering, whenever the crop is of a nature or of a size to admit of the "cultivator" being worked—this is in order to break up the caked surface which follows flooding, and to maintain a top layer of finely divided soil known as a "mulch" in American parlance. This "mulch" is very effective in retaining the moisture in the lower soil by checking evaporation as is proved by exhaustive experiments carried out by the Irrigation Investigation Bureau, the results of which are given in the following table abstracted from the *Agricultural Year Book* of 1908 :—

Period of test.	No mulch.	3″ mulch.	6″ mulch.	9″ mulch.
1st test 21 days, June 10th to July 1st ..	21·92	5·16	2·06	0·32
2nd test 32 days, September 1st to October 3rd	34·59	14·71	5·93	0·75

The figures represent the percentages of the water applied in 6″ waterings lost by evaporation during the two periods.

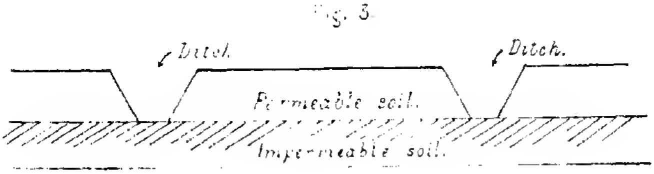
The experiments have led to the development of two new methods of applying water to the crops known respectively as "Winter Irrigation" and as "Sub-Irrigation."

"Winter Irrigation" consists in breaking up the subsoil by a machine which loosens without turning it to a depth of about 18″ thereby increasing its capacity for holding water—then thoroughly soaking the land by surface flowing at a time when the water is otherwise not required for irrigation and, as soon as the surface is dry enough, ploughing and working up the top 6″ into the desired "mulch." Farmers who have tried it say that they are maturing better crops by this method with a very appreciable saving in the total water used—the crops requiring but one or two other waterings instead of the 4 or 5 formerly necessary without winter irrigation.

The same principles underlie the system of improved "Dry Farming," as it is called, which aims at conserving the rainfall by rendering the soil more readily receptive of the rain as it falls and by subsequently checking its evaporation.

"Sub-Irrigation" aims at supplying a sufficiency of water to the crop roots without any disturbance of the surface soil. In its initiation it was employed for orchard irrigation only but recently it is being developed for general crops. In a few cases where physical conditions are favourable this system is applied by seepage from ditches run at suitable intervals transverse to the general slope of the ground: the essential conditions are a moderate depth of light permeable soil over harder and more impermeable strata.

Fig. 3.



The lower ditch acts as a drain to prevent undue water-logging and the system is kept running so long as the crop shows no signs of getting too much water.

There are several tracts in California where this method is employed with marked success and with great economy of water depths per acre. This is however exceptional and clearly dependent on the required physical conditions: the more usual method of "Sub-Irrigation" is by means of pipes. The first pipes used were ordinary drain pipes laid from 1 foot 6 inches to 2 feet below ground surface with open joints through which the water percolated into the soil, and at first the system was applied to orchards, one line of pipes being run along each line of trees. It was found however necessary to give a pipe line along each side of each row as otherwise the roots were attracted to the pipe line and the tree growth became irregular. It was also found that the roots made their way into the pipes through the open joints, blocking the pipes. This defect has been

met by several forms of patent pipes, such as of honeycombed concrete permeable to water but said to be impermeable for the roots. These appear to be made by restricting the cement matrix so that it will not fill completely all the spaces in the ballast or gravel. Another method is to give small upright pipes perforated and accessible from the top at each tree, so that they can be kept clear of roots, the pipes between the manholes having cemented joints. The success and economy of water applied by this method in orchard irrigation has led to experiments with the same system for general farming. The water is fed from a main pipe under pressure into branch pipes or laterals, spaced from 30 feet to 100 feet apart depending on the soil; each lateral is under complete control by means of a valve at its point of departure from the main pipe.

The Wiggins system is the most recent development, and is now being demonstrated at Garden City, Kansas. The writer was told by two or three farmers who had seen the system working during the last season that the crops raised were excellent and very even in quality, showing no difference along the pipe line. The Irrigation Investigation Officers, however, are doubtful whether the spacing of the pipes at such wide intervals as even 30 feet apart will prove effective for general crops, and while admitting that the Garden City experiment is on a thoroughly practical scale and has been successful this year, they state that it was favoured with exceptionally good growing weather and helped out by timely rain; they therefore do not consider this year's test conclusive as to the general efficiency of the system as applied to general farming in ordinary or dry years.

Pumping. As already noted, the exhibits of irrigation plant at the Congress were very limited, and it was impossible to gather from them any new information of value. It appears that many of the artesian supplies near Denver, which ran freely when first tapped, have since become so reduced as to require the application of mechanical pumping.

There are several large and successful pumping installations in different parts of the States, but so far as could be ascertained

from enquiry the water bearing strata are either gravel or coarse sand. No improved methods of pumping from a water table in fine sand subsoil, a solution of which problem is of such prime importance to India, could be learnt. Gasoline driven pumps appear to be more generally adopted than any other form, owing to the small amount of supervision they require and to the readiness with which they are started.

THE CULTIVATION OF RICE IN SPAIN AND THE RECENT INTERNATIONAL RICE CONGRESS AT VALENCIA.

BY

E. J. BUTLER, M.B., F.L.S.,

Imperial Mycologist,

(Official Delegate for India).

RICE CULTIVATION IN SPAIN.

AMONGST the rice-growing countries of Europe, Spain occupies the second place, with 96,000 acres devoted to the crop, against 360,000 in Italy. In the other southern countries the amount grown is insignificant; Bulgaria has commenced the cultivation, the new provinces of Greece contain two or three thousand acres, and there are some hundreds in the Rhone Delta in France, where an effort is being made to popularise the crop. One of the chief difficulties in the way of an extension of the area is the prejudice which exists against rice growing in populous tracts, owing to the danger of inducing malaria; and one of the most interesting discussions at the recent Congress arose from an attempt to show that this prejudice is unfounded, provided that certain precautions are observed. If this view gains credence, it can hardly be doubted that there will be a material increase in the European production of this cereal.

The cultivation of rice in Spain is limited to the East coast, and nearly three-quarters of the area is situated in the province of Valencia. The greater part of this is permanent rice land, unlike what exists in Italy and Greece where rice is grown in rotation with other crops. In this, and as will be evident later on in many other particulars, the cultivation in Spain approximates more closely to that of India than elsewhere in Europe.

The rice-growing district of Valencia is a plain between the mountains and the sea. The slope is gentle, and towards the sea

Plate XXIX

Fig. 1. PUDDLING THE SEED BED.

Fig. 2. PUDDLING WITH [illegible]

the land is almost level, of slight elevation, and naturally marshy. At one place it is broken by the large lake, or more strictly speaking lagoon, of Albufera, whose shores are ill-defined and merge into a plain of rice fields recalling the swamp rice lands of the lower delta of the Ganges and Brahmaputra in Eastern Bengal.

The whole of this area is supplied by a magnificent system of irrigation canals derived chiefly from the rivers Jucar and Turia. Though irrigation was apparently practised in the time of the Romans, its full possibilities were not achieved until the Moorish conquest, and it is to the Moors also that the introduction of rice cultivation is due. It is highly probable that many of the distinctively oriental practices followed, and in particular that of transplanting, unknown elsewhere in Europe, are to be traced to the prolonged occupation of this district by an Eastern people.

Since the cultivation of rice in Valencia has been probably brought to a higher pitch of perfection than anywhere else in the world, a brief description of the methods followed, as far as it was possible to ascertain them in the time available, should be of interest.

The seed beds are placed in higher land than the final rice fields, as in India, and are frequently many miles away from the latter. The district of Alberique, near the head waters of the irrigation system of the Jucar, is reputed especially suitable for growing seedlings, which are exported freely to the lower districts towards the sea. Their preparation offers nothing special, except that they are frequently green-manured or receive a heavy dressing of mineral fertilisers similar to that applied to the main fields. They are puddled before sowing in order to render the sub-soil impermeable. This is done by driving horses up and down, with or without the use of harrows (see Plate XXIX, Fig. 1).

The main rice fields are still covered with water at the time of harvest in September-October and are left to dry out gradually. They receive a working in the mud or while covered with a shallow layer of water in January or later, according to the district. This is done with harrows, derived from the Acmé and disc harrows (several forms are in use), specially calculated to cut up and bury a weed which is one of the chief troubles of rice cultivation in Spain,

Leersia Oryzoides L. In order to render the lower lands, where the soil is a heavy tenacious clay, more easily worked after drying, a special harrow, the "rallaora," has been introduced, which is run through while the land is still moist. It consists of large discs over a foot in diameter and set about a foot apart, which simply make vertical cuts in the soft soil: the draft is said to be exceedingly light.

The fields are now dried out completely and when dry receive the most important working of the year, a thorough ploughing

Fig. (a). Charuga.

with heavy draft inverting ploughs. Modified Lincoln ploughs ["charuga" Fig. (*a*)] were formerly and are still extensively used for this purpose but are now being replaced by double Brabant ploughs, which require two or three horses to draw them [Fig. (*b*)]. It is not so long ago that the "forcat" [Fig (*c*, p. 330)], which recalls the native Indian plough, was in general use, and the cultivators of Valencia consider the introduction of inverting ploughs one of the greatest advances that has been made in their hereditary occupation. Its effects have been far-reaching, and an interesting paper was presented to the Congress describing the modification in the local breeds of horses caused by the need of a more powerful animal than the Andalusian horse to draw these ploughs and met by the import of Breton mares and colts; nearly two-thirds of the horses of Valencia are now of French or mixed origin.

The object aimed at in this ploughing is to leave the soil exposed to the action of the atmosphere in large masses and to dry it to as great a depth as possible. Nevertheless, in the heavy lands near

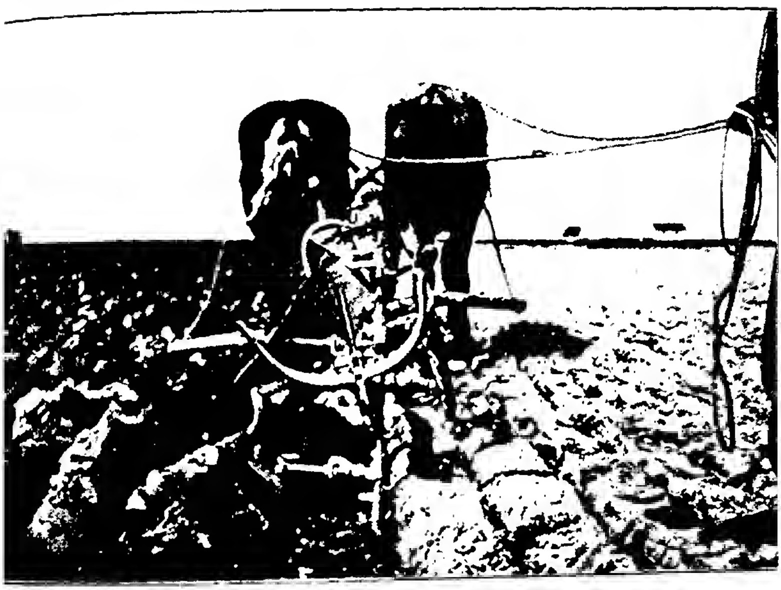


FIG. [illegible].—DOUBLE BRABANT PLOUGH.

Albufera, a depth of 5 or 6 inches is not usually exceeded. The use in these lands, of the "rallaora," the cracks caused by which are said to expand as the soil dries out in the early months of the year, serves the double purpose of deeper aeration and of making the work of the heavy plough easier when the time comes for its use. It will be seen that the question whether cold weather cultivation is advantageous or not in swamp rice culture, a debated one in India, has been decided in the affirmative in Spain. There is even talk of introducing steam or motor traction to reduce its difficulties and expense and to render it more thorough.

In May, a few days before the time for transplanting arrives, the water is run in again and a final puddling given which destroys any further growth of *Leersia Oryzoides* and reduces the permeabi-

lity of the soil. The "draga" or modified Acmé harrow is used for this (see Plate XXIX, Fig. 2), but a better implement for the purpose is stated to be the Sargenti harrow, also derived from the Acmé and highly spoken of in Italy.

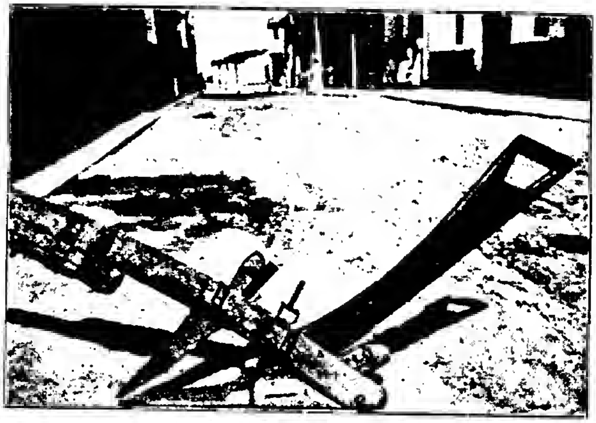


FIG. (c).—FORCAT.

The fields are very heavily manured. Leaving out green-manuring, which is chiefly practised in the higher lands as in the Alberique district, it is customary to give heavy dressings of sulphate of ammonia and superphosphate * and many add a potash manure. A common mixture is sulphate of ammonia 40 per cent., superphosphate 54 per cent., and sulphate of potash 6 per cent., and this is used at the rate of 600 to 800 lbs. per acre. The time of application varies but usually half or three-quarters is applied a day or two before admitting the water prior to transplanting and the rest three or four weeks later, the water being run off for the purpose; sometimes, however, all is applied before transplanting. In Alberique guano is said to be largely used at about the same rate. Cyanamide is at present being vigorously boomed. It is of interest to note that nitrates of potash and soda are said to be entirely unsatisfactory an

* The soils of this region are deficient in phosphoric acid, which is rarely found in the proportion of 1 per 1000.

experience which is in harmony with recent views regarding the form in which nitrogen is assimilated by rice. The opinion was expressed that the use of sulphate of ammonia has been carried to excess, and in the first report (for the year 1913) of the Experimental Rice Station of Sueca (near Valencia), the Director, Señor E. G. Montesoro, gives strong support to this view as a result of a carefully devised series of experiments. In the same report doubt is thrown on the necessity for adding a potash manure to the rice lands of Valencia, and there was a lively discussion on the subject in the Congress, the balance of opinion being against potash manuring.

Experiments have been carried out at Valencia for several years to test the action of manganese, which has been found in Japan to augment considerably the yield of rice. The results are in contradiction with those obtained in Japan, but as a little manganese is already present in the local soils it is not denied that beneficial results may be obtained where this element is entirely deficient. Further, Dr. H. C. Oria, Professor of Organic Chemistry at the University of Valencia, presented a paper in which he suggested that the beneficial action of manganese is to be traced to its rôle as a catalyser, resulting in the better oxygenation of the roots, and that for this to be fully exercised certain requirements must be fulfilled. These are that the manganese should be in the form of carbonate, either added as such or formed by reaction with potassium carbonate and that there should be organic acids in sufficient quantity in the soil to decompose the carbonate and form organic salts of manganese of high molecular weight. He attributes the contradictory results in Japan, Italy, and Spain to failure to observe these conditions uniformly.

Transplanting is done in a few inches (3 to 5) of water. The seedlings, after being taken from the seed bed, have the soil very completely washed from the roots and are put up in bundles of 4-500 plants for transport to the fields. A delay of 24 hours in transport does not seem to be thought excessive. The relation of seed bed to field in area is 1 to 10 or 12, and about 250 bundles are used per acre. The transplanters work backwards, and every movement of the operation is exactly as in India (see Plate XXX, Fig. 3).

Each clump contains 3-5 plants (single seedling transplanting appears to be unheard of) and the distance between the clumps is 8 to 10 inches. Six men will transplant a hectare (2·47 acres) in a day and they were being paid this May 5 to 6 pesetas (3/10 to 4/7) a day.

FIG. (d).—TREADING OUT THE GRAIN.

As in India the crop requires little attention during its growth period. The chief operation is the *airago* or running off the water in June, when the fields are weeded and a part of the manure is frequently added. Harvesting is done with the sickle, and the grain is still usually trodden out by horses and the feet of the labourers who are armed with wooden forks for turning over the straw [Fig. (d)]. It is freed from the chaff by throwing into the air, sufficient wind for the purpose being rarely wanting at the time [Fig. (e)]. Winnowers are little used. Of late threshers have come in and there are now many of all sizes and of special types suitable only for rice. The large installations have reduced the cost of threshing by nearly half. They are driven by steam, elec-

Fig. 3. TRANSPLANTING RICE IN SPAIN.

Fig. 4. VIEW AT HARVEST.

tricity, or gas, and are said to be thoroughly satisfactory.* The further preparation for the market is carried out in modern mills equipped with machinery which is much the same as that in use elsewhere, rice milling machinery being now of a practically universal type. Polishing is practised on a comparatively small scale only.

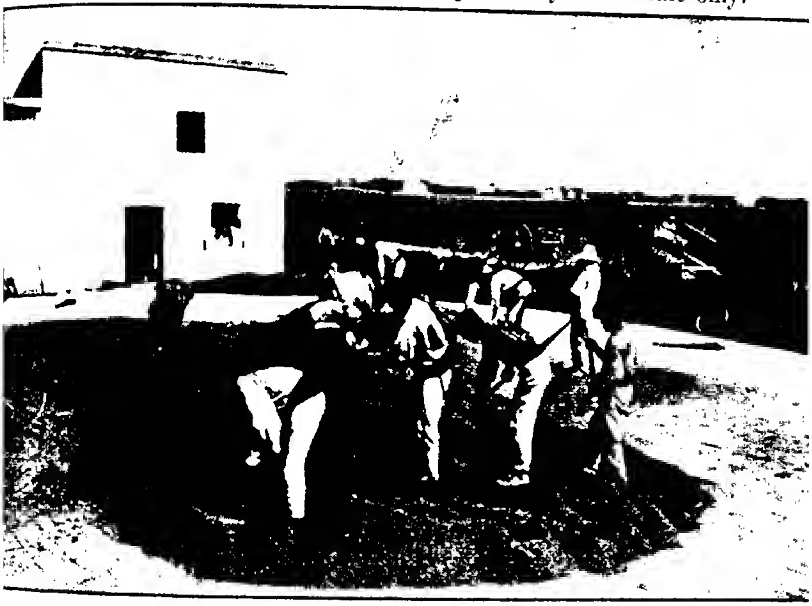


FIG. (e).—CLEANING THE CHAFF.

The following table gives the yield of rice in Spain in 1913, as compared with that of other countries †:—

Country.	Area under rice in acres.	Production in tons.	Yield per acre in lbs.
Spain ..	96,000	246,000	5,700
Italy ..	360,000	534,000	3,300
Egypt ..	254,000	375,000	3,300
Japan ..	7,393,000	7,026,000	2,100
United States ..	827,000	517,000	1,400
India ..	70,580,000	28,167,000	890 (This must be a rough average only. There are many districts in Bengal and Madras where the yield is double.)

* The chief makers are Domingo Gomez Fils of Valencia.

† The figures supplied to the Congress were quoted from the *Bulletin of Agricultural Statistics of the International Institute of Agriculture*, Rome, March, 1914

From the above it will be seen that the average yield per acre in Spain is almost double that obtained in Italy and more than six times the Government figures for India. The excess over Italy is partly to be traced to the practice of transplanting, universal in Spain and unknown in Italy; over India to heavy manuring, better cultivation by means of specially suitable implements and, to a less extent, better varieties.

The study of varieties of rice was the first subject discussed at the recent Congress. It has not been taken up seriously in Spain until very recently but its importance seems now to be fully recognised. In Italy it has been energetically carried on at the Station for Rice Cultivation at Vercelli and elsewhere, during recent years, with remarkable results. Both Italian and Spanish authorities appear to be agreed that the continued cultivation of a variety without selection in the same locality leads to degeneration and the appearance of the destructive disease known as *brusone* and that one of the most important factors in successful rice cultivation is the succession of new varieties obtained by importation and selection. Accordingly one of the chief subjects taken up at the newly established Rice Station at Sueca (Valencia) is the study of varieties, both imported and indigenous. Having in view the remarkable success obtained in Italy with varieties of Japanese origin, a number of these have been imported and several give promise of being suitable for cultivation in Spain. Little attention appears to have been paid as yet to Indian varieties in Europe.

In resuming this short account of the highly perfected cultivation of rice in Spain, three things seem particularly calculated to arrest attention: The universally accepted importance of a thorough cold weather cultivation of the fields, rendered possible by the use of specially adapted implements*; the necessity for employing considerable quantities of suitable nitrogenous and phosphatic manures; and the value of introducing exotic varieties with a view

* The Station for Rice culture at Vercelli (Novara), Italy, has in preparation a detailed account of the results of a very complete series of experiments with all the implements suitable for rice cultivation that they have been able to get together, with data of construction, draft and efficiency, and the volume should be essential for any one requiring fuller information on this subject.

to checking deterioration of races long cultivated in the same environment. All these appear worthy of more detailed consideration than they have received in India. though the first two present difficulties in the way of their introduction on any large scale under present economic conditions. and particularly the second in view of the inferior draft animals available in the greater part of the rice-growing tracts of India. But the results in Spain have been obtained on a system of cultivation which. unlike that elsewhere in Europe. is fundamentally the same as in India. and we have no such difficulties to face as confront the Italians. for instance. in the attempt they are making to introduce transplantation.

The 5th International Rice Congress

The subjects set down for discussion were arranged under eight heads. each of which was assigned in advance to a special local committee. with a view to preparing notes to serve as a basis for discussion. Each of these heads was then submitted to a Section of the Congress. but as the Sectional meetings were arranged so as not to clash. they became. in practice. meetings of the full Congress.

The conclusions were drawn up in a series of resolutions which were submitted for formal acceptance at the final session of the Congress. The proceedings lasted a full week. from the 17th to the 24th May. 1914. Excursions were arranged to the chief centres of rice cultivation in the neighbourhood. and also a visit to an up-to-date rice mill. No effort was spared by the local executive committee. the organising genius of whose President. the Count de Montornés. was much in evidence during the week. to make the meeting a success. Like most assemblies of the kind. the formal sessions were of less value than the opportunity afforded to the delegates of learning something of the actual agriculture of the country and of discussing their problems together outside the Congress. As was fitting. in view of the lead which Italy has taken in the scientific and practical study of rice cultivation, the Italian delegation was the most important. both in numbers and authority,

and included several members of the staff of the well-known Station for Rice Culture at Vercelli, headed by their Director, Signor Novello Novelli. Other countries represented were England, France, Greece, Portugal, the Argentine, China, Colombia, Guatemala, Indo-China, and Venezuela. It is impossible to avoid referring to the extraordinary cordiality of the reception offered to the members of the Congress by the various public bodies of Valencia and by the people as a whole.

The first subject taken up was the study of varieties of rice, their importation, and the preservation of their characters by selection. In the note presented as a basis for discussion, stress was laid on the unsatisfactory nature of the classifications available of the varieties cultivated in Europe, both from the agricultural and the scientific point of view. It was pointed out that the same variety was known by several different names according to the locality in which it was grown, and that the constant multiplication of so-called varieties had led to the greatest confusion. Accordingly it was suggested that the first step necessary was the formation of a true botanical classification of the varieties of rice under cultivation. This suggestion clearly did not take into account the enormous difficulties of the task imposed, and several speakers insisted on the fact that a true botanical classification of rice, which would deal in a satisfactory manner with all the varieties cultivated in various parts of the world, was not yet possible. The classifications made by Kikawa in Japan and Graham in the Central Provinces in India were referred to as indicating the immense number of varieties which would have to be included, and the difficulty of deciding on characters which would stand the test of preserving their uniformity under different conditions of the environment. The following resolution was finally adopted:—
"That the botanical study of the varieties of rice cultivated should be taken up in all countries, and that each should make a provisional classification founded on characters which might be considered as fixed; as soon as some of these characters have been established, they should be communicated reciprocally between the institutions which, in each country, are charged

with this study, in order to arrive at a unification of method."

In dealing with the importation of varieties no hesitation was shown in advancing the proposition that this was of supreme value in checking deterioration of the crop. The present writer is not aware that the subject has ever been regarded in this light in the East; certainly it has not been seriously considered in India. But Italian experience has led to the definite acceptance in Europe of the view that rice long cultivated in the same locality degenerates, and that it is necessary to import and acclimatise new varieties and to preserve their vigour by local selection, and the exchange of seed between fields which differ in soil, water, and other environmental conditions. In other words, the experience which has been pretty well universal with regard to crops which are propagated vegetatively, such as sugarcane and potato, is held to apply to rice also, though propagated by seed. In importing varieties it was advocated that care should be taken to select sorts likely to be really adapted to the locality through having been grown under similar conditions in the country of origin. This is an aspect the importance of which seems liable to exaggeration: naturally one would not import Indian deep-water rices for trial in the higher lands at Alberique: but to insist, as the note presented to the Congress did, on the necessity of having with each variety an analysis of the soil in which it was grown and of the irrigation water, with details of the quantity and composition of manure employed, the methods of cultivation, the prevailing winds and their maximum and minimum velocity, and so on, is certainly to go beyond reasonable requirements. The resolution on this subject "That the exchange of seed should be made by official centres in the different rice-growing countries, the samples being always accompanied by a history of the variety," is, however, sufficiently indefinite to allow of free interpretation.

The selection of seed is little understood and less practised in Valencia. It is, for instance, startling to read in one of the papers presented to the Congress that "Providence has assigned to all plants a certain limit of production, and when man, pushed

by his boundless ambition, forces them to overstep the limits which natural law has imposed on them, their degeneration is immediate and their death near." Little of value emerged from this part of the discussion and the resolution "That every country should adopt the same method of selecting seed" is not likely to commend itself just yet to the botanists engaged in the study of rice.

The second Section dealt with the methods of assimilation of fertilising substances by rice and the most modern methods of manuring this crop. An interesting paper was read by Siñor E. Herrero, recording the results of experiments to determine the rate at which the chief elements are absorbed, and the relative requirements at different periods of development of the crop. The results obtained showed that 72 per cent. of the dry matter was formed between the time of transplanting and the completion of vegetative growth, a period of 52 days. In this period the absorption of nitrogen kept pace with the increase in the dry matter, the absorption of phosphoric acid was proportionally more rapid, and that of potash was intermediate. From completion of growth to the formation of the ear, a period of 22 days, the nitrogen still kept fairly parallel to the dry weight but the potash diverged widely, reaching its maximum of absorption in this period; the phosphoric acid absorbed also, considerably exceeded its proportionate quantity. In the period, also of 22 days, from the formation of the ear to ripeness, the nitrogen continued to be absorbed at a rate parallel to the increase in the dry weight, but the potash fell away greatly; the absorption of phosphoric acid continued to increase, but at a less rapid rate now than the dry weight. As the absorption takes place by the roots, the relative proportion of roots to above-ground parts at different periods is of importance in considering the amount of assimilation they can perform, and the consequent need of providing the elements in a readily taken up form. The examination of this factor showed that the roots being relatively less toward the end of development, while the absorption of nitrogen continues to keep pace with the increase in dry matter, each unit of assimilating root-area is called on to provide nitrogen at a more rapid rate in the last period of development than earlier. Hence there

seems to be a need of supplying nitrogen in a readily available form at this period. This does not apply so much to phosphoric acid, the absorption of which slackens at the end, and not at all to potash, which ceases to be absorbed after the formation of the ear.

In the discussion much time was occupied in the advocacy of the use of potash and cyanamide by the representatives of these industries, and in the case of the latter a good deal of evidence was offered to prove its value for rice. A resolution was finally adopted that "the Congress while applauding the interesting study made by Señor Herrero on the assimilation of fertilising elements by rice, which is of remarkable interest in the technique of manuring rice, expresses the wish that such studies should be continued and completed in regard to the kind of manure which is suitable, as well as the best periods for its application: and that also the scientific study of the action which different manures exert on the rice fields, both as to their utilisation and profitableness, should be taken up."

In the third Section, the subject considered was the operations of cultivation, of harvest, and of elaboration, and the machines most suitable for perfecting these operations and reducing their cost, especially in small holdings. An exceedingly interesting and lucid note was presented by Señor E. L. Guardiola, one of the General Secretaries of the Executive Committee, giving an account of the implements and machines in use in Spain, and of some foreign ones worthy of trial. This was supplemented by Prof. Tarchetti, one of the leading authorities in Italy on this subject, who described the advances made in that country in recent years, which appear to be very striking. It was surprising to learn that the number of machines specially devised for the different operations in the cultivation and harvesting of rice runs into dozens, but as their description is unintelligible without diagrams, it is necessary to await the promised volume referred to in the foot-note on p. 335 for fuller information. The importance of the subject was felt to be such that the Congress adopted the following resolutions: "(1) It would be advisable to publish, from an international standpoint, a Review to be the official organ of the different stations for rice

culture in the world, which would describe the methods employed in each country, and would deal in particular with the study and wide diffusion of machines calculated to perfect the cultivation of rice both in small holdings and on a large scale, while reducing the cost. The International Institute of Agriculture would perfectly fulfil this mission. (2) From the point of view of cultivation in Spain competitions of motor ploughs, as well as of dryers and harvesters, specially suitable for rice, should be organised."

Another Section was occupied in considering a subject arising out of the last, namely, the influence which has been exercised on the equine population of Valencia by the improvement in the methods of cultivation of rice. The facts of the case were set out in a very full note by Señor R. J. Janini, who showed that between 1861 and 1891 the Andalusian breed, which was formerly found in the agricultural districts of Valencia, was in great part replaced by French horses, and that this has continued, until now, nearly two-thirds of the local horses are French, which are imported at the rate of about 1,500 a year, chiefly from Brittany. The Spanish horse is too light for the heavy work now required in the rice fields. It was suggested that Spain had lagged behind the northern countries of Europe, especially France and England, in the improvement of horse breeding, though starting with probably better breeds than were available in these countries, and that this industry, so important for the agriculture of the country, was worthy of every encouragement. The following resolution was approved:—"The Fifth International Rice Congress respectfully prays the General Association of Stock Breeders of the Kingdom to examine the lines on which horse breeding should be undertaken in order to stimulate vigorously the production in the Eastern provinces of Spain of breeds suitable for agriculture and for the army."

The fifth Section discussed recent work on the diseases of rice. The most destructive of these is the condition known as *brusone* in Italy or *faille* in Spain, which in some years causes very great losses. It appears to occur throughout the world wherever rice is grown, having been signalled in the United Sates, Japan, Java, and India. At the same time, it is probable that a number of

distinct affections have been confused under the same name and even in Italy, where it has been under observation for many years, different authors are by no means in agreement on its symptoms. In India the problem is being approached in the first instance, by separating out from the conditions which lead to failure of the grain to reach maturity, those which can be definitely traced to the attack of parasitic organisms such as fungi. Some of these have certainly in the past been confused with true *brusone*, and their study is a necessary preliminary to the more accurate limitation of the disease. It appears probable that when all these parasitic diseases have been defined, there will still remain a considerable residue in which the failure of the crop cannot be attributed to the action of any parasitic organism. It is to this alone that the term *brusone* should be applied.

In the discussion, general agreement was shown in considering *brusone* as a physiological degeneration hastened by the action of ill-defined external conditions, climatological as well as cultural. It is interesting to note that in Spain the prevalence of West winds is considered to predispose to *faille*: in India the same is said of South winds in certain localities. Other predisposing causes mentioned were deficiency of oxygen in the water, impoverishment of the soil, and abrupt variations of temperature at certain periods. As a means of reducing the losses caused by *brusone* in Italy, the introduction of exotic varieties of rice was tried some years ago. Success was obtained very quickly and further work in this direction was energetically taken up at the Vercelli station and elsewhere. The Director of the last named institution now considers that by this means a satisfactory method of fighting the disease has been found. Where the new varieties (chiefly of Japanese origin) have been introduced and where, in addition, care is taken not to grow any one variety too long in the same fields and under the same conditions, *brusone* has lost its terrors. Whether this supports the Italian view that *brusone* is a "physiological" condition and not a definite disease is doubtful. Very similar experiences have been met with in the red rot of sugarcane, which is nevertheless certainly caused by a fungus. All that it seems safe to admit at

present is that none of the various parasites to which the disease has been attributed can be accepted as the true cause ; it is clear that there is still a vast field of work to be covered before this can be elucidated ; but it is equally clear that the Italian methods of combating the disease are worthy of imitation in India and elsewhere that it occurs.

The Congress adopted the following resolutions in this Section :

"(1) It is absolutely indispensable to nominate an International Commission to draw up the plan to be followed in order to determine the factors which are concerned in the phenomenon of *faille* or *brusone* of rice. This Commission may adopt the following limits, (*a*) nature of the soil in which the experiments are made ; (*b*) comparative study of the systems of irrigation employed, the depth of the layer of water and its composition, abrupt changes of temperature and mean temperature during the different phases of vegetation, rapidity of flow of the water, etc. ; (*c*) manures employed, their composition, quantity, etc. ; (*d*) study and selection of the seed used for the experiments ; (*e*) experiments with radioactive fertilisers and "thorianisation" of a part of the seed used ; (*f*) comparative study of the resistance to certain diseases of each variety of rice under similar conditions. (2) It is necessary to catalogue the species of the animal and vegetable kingdoms especially insects and cryptogams, injurious to rice ; it is equally necessary to protect effectively the birds not recognised as injurious to agriculture, seeking to convince cultivators and the country in general of the necessity for this protection in order to combat the numerous insects which damage all kinds of crops. (3) The various stations for rice culture and for vegetable pathology should carry on experments with a view to prevent or to combat the animal and vegetable species which cause disease in rice. (4) It is advisable to establish in each rice-producing zone a meteorological station charged with the study of the influence of different meteorological phenomena on the development of certain diseases of rice."

To the sixth Section was assigned the consideration of the world's commerce in rice, and the advantage of international regulation to guarantee the authenticity of marks and origins of the

produce on the market. The note presented described the objects for which rice is employed, the manner in which it is prepared for the market, the variations in price due not only to the quantity produced but still more to the competition of other food grains, the disadvantage under which rice labours in not being considered an article of necessity but a luxury and, therefore, in being exposed to heavier duties and taxes in many countries than other cereals and the difficulty in preventing fraud in the use of marks and indications of the locality from which the produce has come. Amongst the points of interest to India which arose was the active propaganda which is being carried on to popularise the use of rice in districts where it is considered a luxury and is unknown to the poorer classes. This is the case even in Spain where a considerable part of the local produce is exported. Another was the effort which is being made to reduce the cost of internal transport, which is at present so heavy that Indian rice can be delivered in certain parts of Spain at a lower price than that grown in the country itself. The heavy tariffs in force in some countries were also attacked, as presenting a serious bar to the general use of the grain. In France the produce of the French colonies (chiefly Indo-China and Madagascar) is admitted free, while that of other countries is taxed. Most other countries in Europe tax rice more heavily than other cereals.

The following resolutions were passed: "(1) To carry on a very active propaganda to make known the usages and the applications of rice by means of conferences, the distribution of illustrated pamphlets, samples, and recipes for its preparation. (2) To endeavour to reduce the price of rice by perfecting the cultivation and employing the best and most productive varieties. (3) To perfect the preparation and complete utilisation of the residues so as to diminish the market price, while at the same time seeking to avoid an increase in this price due to the intervention of many middlemen between the producer and the consumer. (4) To secure rebates or suppression of the internal duties which press heavily on rice and the recognition of this aliment as a necessity comparable to wheat and other cereals. (5) To secure reduction of transport tariffs in order to facilitate access to markets whether

internal or foreign. (6) To secure concerted action by Consular bodies, Chambers of Commerce, and other similar bodies, by the agency of an International Convention, to prevent the improper use of names or marks or their falsification and to assure the authenticity of the origin by means of irrefutable documents. (7) To secure a concerted understanding between all the States which produce rice, with a view to establish between them effective legislation and international action against the improper and fraudulent use of marks as well as of all that might mislead the consumer in regard to the origin of the produce, above all requiring that the latter be supported by credible documents.

In the seventh Section there was a very lively discussion on the subject of Co-operative Societies of Production and Consumption as applied to rice. In the former category was included co-operation to assist in the supply of choice seed, in procuring manures and implements, and in furnishing advice regarding sowing, manuring, cultivation, irrigation, and the prevention of disease. In the latter, societies which encourage and facilitate transactions of sale and secure the export of the produce to the chief centres of consumption. It was suggested in the note submitted for discussion that the Societies of Production, of which there should be one in each distinct tract, should maintain an experiment station for the introduction and testing of new varieties, selection of seed, analyses of manures, trial of implements and so on, in addition to their other functions. The Societies of Sale should handle all the rice produced by the members, have it graded by experts, and effect its sale without the intervention of middlemen. In the discussion, considerable opposition to the formation of Societies of the latter category was encountered and the supporters failed to secure unanimity. The final resolution adopted was that "It is advisable to found Co-operative Rice Societies of production by zones, whose boundaries should mark the differentiation of essential agricultural characters. These Co-operative Societies should federate to form large unions for the protection of their general interests, for the organisation of sale in the country of production, and for export to centres of consumption."

The last subject discussed was paludism and the cultivation of rice. An exceedingly interesting paper was presented for discussion by Señor I. G. Colmenares, Regional Health Inspector, on behalf of the local committee. This commenced by a criticism of the restrictive legislation in force in Spain in regard to rice cultivation, the foundations of which date from 1862 and were naturally based on the views regarding malaria then current. The chief clauses prescribe that the land should be marshy and unfit for any other kind of cultivation, without woods or forests or obstacles to the free circulation of the wind, that it should be at least 1,500 metres from any inhabited spot, that it should command sufficient water for irrigation, and that the drainage should not interfere with neighbouring properties, for which purpose the construction of a canal or ditch around the land is imposed. These provisions were natural enough when malaria was believed to be caused by the miasma or effluvium from stagnant water diffused into the air and capable of acting at a certain distance. They aimed at keeping the rice fields away from dwellings, and at dispersing the effluvium by the wind.

The author of the note drew a distinction between the forms of paludism special to localities naturally marshy, abandoned and without cultivation, where alone the grave æstivo-autumnal type of fever is found, at least in Spain, and the milder form, distinct both clinically and pathologically, found in cultivated localities. When cultivation is being introduced into marshy land the two forms are often found together, and it can be readily understood that the immigrant population are inclined to attribute both to the cultivation. Rice cultivation has naturally been pursued largely in swamp and delta lands, already subject to the graver type of paludism. The incidence of æstivo-autumnal fever amongst rice cultivators was therefore heavy in the earlier days of the spread of the crop, and the prejudice thus caused has interfered with the recognition of the fact, familiar to medical men, that the ultimate effect of this cultivation has been the amelioration of large areas in so far as this type of malaria is concerned. Under such circumstances the cultivation of rice becomes a valuable method of

sanitary improvement, and instead of being restricted should be encouraged by the State.

The conditions under which rice cultivation is hygienically safe were next considered briefly. It was stated that the rice-fields themselves, when suitably established, served only exceptionally as breeding places for anopheline mosquitoes, but that these occur freely in the canals and ditches, where the water is allowed to stagnate, and weeds and debris accumulate. In the fields one finds hardly 1 per 1,000 of the anopheles which transmit malaria, infected, and in the huts where the labourers keep their implements, and which are found scattered through the fields, none are infected; in the villages, on the other hand, the number rises to 5 per cent. It has been found that by suppressing the small breeding grounds, pools, wells, &c., in the villages malaria disappears. It should be noted that this does not refer to æstivo-autumnal fever, which is stated not to occur once the land has been brought under cultivation. The provision that rice should not be grown where other cultivation is possible is not strictly observed, and the author believes rightly. What the law should consider is whether the soil is sufficiently drained to prevent the formation of permanent marshes. Equally important is to insist that the quantity of irrigation water available is sufficient to preserve a constant current in all parts of the area, including the channels of supply and drainage. The law should aim at the prevention of the formation of areas similar to the marsh lands where æstivo-autumnal fever is spontaneous.

With regard to the prohibition of obstacles to the circulation of the wind, the author holds that it is difficult to find facts in favour of this restriction. On the contrary, it is more reasonable to suppose that barriers might be effective in limiting the area of dispersion of the mosquitoes, and that under certain circumstances woods or avenues of trees might be a defence against infection. The minimum distance laid down by the law to intervene between the fields and dwellings is also not in accord with the facts. The form of paludism which rice cultivation might induce is the same as that liable to be caused by any other badly established cultivation

under irrigation, and requires no distinctive legislation. Properly carried on (in the words of a very competent expert), rice cultivation might be indulged in without danger at the very door of the church. In practice, the methods of cultivation adopted are as hygienic, as a rule, as they are admittedly excellent from the agricultural point of view.

The conclusions proposed by the local committee in the form of a series of resolutions embodying the above views were open to objection on the ground that they contained a criticism of the existing laws of Spain. The foreign delegates pointed out that they would be unable to express an opinion or take part in voting on them. Accordingly they were replaced by the following, which were unanimously adopted:—"(1) That the cultivation of rice modifies land subject to malaria in the direction of making it more healthy. (2) It is advisable to facilitate the making more healthy of obviously marshy lands, even when they are found at a less distance than that authorised by the law."

It will be seen from the above exceedingly condensed review that the subjects dealt with covered a very wide field and that most of them are of direct interest, in one way or another, to even so remote a country from Spain as India. The individual delegates profited as much by the opportunities afforded of getting into relations with the representatives of other rice-growing countries as by the Congress meetings proper. Much of the success of the meeting was due to the personal efforts of the Count de Montornés, one of the foremost proprietor-agriculturists of Spain, whose model estate was well worth a visit. His extraordinary energy in and out of the Congress was evident at every turn. Each delegate was made to feel that it was the special object of the President and local committee to obtain for him every information that he might desire, and to give him every facility in getting into touch with local and foreign members who might be of use to him. It was in this respect the perfection of organisation. From the technical aspect the contributions of the Italian delegates were the most important. Their description of the work done in Italy on the testing of new varieties, on the introduction of improved

implements, and, in particular, of the methods adopted in fighting *brusone*, of which no complete account has been published, were of great interest.

The next Congress will be held in Marseilles in the summer of 1916.

NOTES ON THE FODDER PROBLEM IN INDIA.

ARRANGED BY

J. MACKENNA, M.A., I.C.S.,

Lately Offg. Agricultural Adviser to the Government of India.

(Continued from page 58 of Vol. IX, Part I.)

IN the first set of these notes which appeared in the last January number of this Journal the present writer recorded the results which had been achieved in efforts to introduce exotic drought resisting plants and also gave in detail an account of what had been attempted in the various Provinces in the way of combating fodder difficulties in times of scarcity.

During the year 1913 two very important and representative bodies considered the question of fodder from the special point of view of forests and from the more general agricultural standpoint. At the meetings of the Indian Board of Forestry which met at Dehra Dun in March, 1913, the utilisation of forest grasses was considered. The basis of these discussions was a note drawn up in the office of the Inspector-General of Forests on the efforts hitherto made to utilise fodder grass from forest lands. It was noted that this utilisation of grass for fodder is of greater importance in Bombay, Madras, and the Central Provinces than elsewhere, and that, in these provinces, the subject has already received much attention. "In Bombay the sole right to cut and collect grass from certain forests has been given to a contractor on the condition that he shall maintain for Government a supply of 25 lakhs of lbs. of baled grass from the 15th April to the 15th October of each year. In Madras the people are slowly learning the value of cut fodder, and in 1911-12 the right to cut grass in certain reserves in which hay has been made

by Government in previous years, was sold at the request of the villagers themselves. In the Central Provinces the policy adopted is to cheapen the cost of cut fodder and to raise the grazing fees. In Assam and Burma, where the rainfall is usually ample, and where grazing is not, as a rule, excessive, the question is not of great importance. In other provinces there are special difficulties, such as almost unlimited rights to grazing, which greatly hamper progress."

The general conclusions arrived at by the Board of Forestry were as follows :—

(*i*) That a given area will supply fodder grass of better quality and in greater quantity when cut than when continuously grazed.

(*ii*) That private enterprise is more likely to effect the object in view than operations undertaken by Government ; but that departmental operations may be necessary in places to give a lead to private enterprise and to show the financial results of working.

(*iii*) That the policy of "cheap grass and dear grazing" as followed in the Central Provinces, but modified to suit local conditions, is likely to lead to the best utilization of fodder grasses.

(*iv*) That the incidence of grazing in open areas should be carefully regulated, and every encouragement given to the extension of the area closed to grazing. In closed areas, grass cutting should be permitted at such seasons as will ensure a maximum annual yield, such areas being situated as near as possible to the centres of consumption.

(*v*) That the grazing of nomadic cattle should be confined to certain fixed areas.

(*vi*) That improved communications are likely to lead to the extension of grass cutting operations.

(*vii*) That the substitution of stall feeding for grazing which, from the point of view of forest administration, is much to be desired is extending slowly in Bombay, in the Central Provinces, and in other places where favourable conditions as to supply and market

obtain; but that the villager is not likely to take generally to stall-feeding until higher grazing fees are imposed.

(*viii*) That the storage of grass by Government is not desirable, except when considered necessary to meet the initial demand at a time of fodder famine.

(*ix*) That the question of transport, in regard both to railway freights and the supply of railway wagons, is a real difficulty. To encourage a more general use of cut fodder, low rates of freight, and a steady supply of wagons at grass exporting railway stations are necessary. In order to reduce the demand for wagons, steam baling presses should be used in places where the outturn is large (say 2,000 tons) since steam pressed bales are only half the size of those of equal weight pressed by hand.

The Government of India accepted generally the recommendations of the Board of Forestry. "They agree that in parts of the country where the demand on the forests for grazing is unusually heavy and is not confined to cattle which can be properly classed as agricultural, the policy adopted in the Central Provinces of increasing the dues for commercial cattle is worthy of consideration. They also recognise the necessity for regulating the grazing incidence and the desirability of using steam presses for baling grass so as to reduce the demand for railway wagons. The question of railway freights for the carriage of fodder was however considered as recently as 1910, and the Government of India are not prepared to urge the railways to make any special concession in this matter, except in times of scarcity.

"Clause (*vii*) of the Resolution was discussed by the Board mainly from the forest point of view, the Forest Department being interested in the matter, because the substitution of stall-feeding for grazing would tend to decrease the demand for grazing in the forests, and to increase the market for the sale of forest grass, which in many places is little utilised at present. The Government of India realise that the question of the substitution of cut fodder for grazing must be fully considered from the general agricultural point of view before any definite or far-reaching policy can be adopted. Experience in Madras, Bombay, and the Central

Provinces suggests however that in certain circumstances and in certain localities action on the lines proposed by the Board may have beneficial results from the agricultural point of view as well as from that of the Forest Department."

The second representative body which considered the question was the Board of Agriculture in India which met at Coimbatore in December, 1913. The subject was dealt with by a Sub-Committee of the Board under the chairmanship of the Hon'ble Mr. H. R. C. Hailey, I.C.S., Director of Land Records and Agriculture of the United Provinces, and the first set of these notes which appeared in the January (1914) number of this Journal was taken as a basis of discussion. The Report of the Sub-Committee on the questions of fodder and cattle foods runs as follows :—

"The fodder question appears to arise in very different degrees of acuteness in various parts of India. In some provinces, such as parts of Bombay, the Central Provinces, the United Provinces and the Punjab, the question turns largely on the maintenance of a sufficient supply to prevent the great loss of cattle in famine years. In other provinces and other parts of the above provinces the danger of anything like a fodder famine is somewhat remote, and the problem centres rather round the prevention of waste and the using to the best advantage of the existing material. In irrigated tracts, for instance, there can never be any actual fodder famine though there may be an insufficiency of supplies owing to the crop system in force. In such tracts it is idle to recommend the growing of drought resisting plants, whereas these may be of great value in dry parts of the country. The problems to be attacked therefore are essentially of a local character and must be worked out from the point of view of particular localities and nothing more than very general recommendations can be made."

The recommendations of the Committee are :—

"(1) *That investigation should be made in each province of the existing sources of fodder supply and their utilization to the best advantage.* Among other possible sources of supply to which attention might be directed are the bye-products of the cotton seed crushing mills. Experiments undertaken at Poona have tended to

show that cotton hulls are of considerable value as fodder. It is also suggested that certain grasses at present grown on a limited scale possess high nutritive value.

"Among possible methods of utilization of existing supplies further attention might be paid to ensilage and to the cutting and storage of grass for hay. The present methods are not merely wasteful but tend to lower the nutritive value of the hay.

"(2) *Encouragement of cultivators to include some fodder crops in their rotation.*—This is essentially a local problem on which no particular recommendations are called for. It appears however desirable to consider whether the object in view cannot be furthered by the lowering of the canal rates for such crops in irrigated areas.

"(3) *Stall-feeding.*—The Committee are of the opinion that no efforts to popularize stall-feeding are necessary. It is being forced on the cultivators in certain tracts by economic conditions and will doubtless be forced on them in a larger measure in the future. It should, however, be pointed out that stall-feeding must as a general rule be more expensive than grazing. As the pressing problem at the present moment is to increase the number of cattle, stall-feeding cannot from this point of view be recommended in substitution of grazing where facilities for the latter are already in existence. Further the Committee would point out that, because in exceptional circumstances and on a limited scale, the sale of grass from forests has proved successful, it cannot be argued that it will prove equally successful in all cases or over wide areas of forests. For instance, in parts of the Central Provinces and Berar, where the jungles encroach on, or are surrounded by highly cultivated cotton tracts, the demand for grass is so keen that it pays to cut the grass and stall-feed; but in most other tracts of the Central Provinces the jungles are more remote so that the cutting and removal of grass from the jungles to the villages for the purposes of stall-feeding appears impracticable. Much of the forest grass too when cut and baled under present conditions is so rank and coarse as to be unpalatable to cattle and possesses a very low nutritive value.

"(4) *Storage against famine.*—Experiments should be undertaken as to the best methods of storing hay and various forms of

fodder and demonstrations of the methods recommended given. The co-operative societies would probably form most useful agencies for carrying out these methods. The experiments now being undertaken in the Bombay Presidency for shredding and baling *karbi* appear to offer a possible solution of storing this form of fodder and, if ultimately successful, the process might be usefully adopted in other tracts subject to famine.

"(5) *Prickly Pear.*—The experiments undertaken in the Bombay Presidency go to show that the prickly pear, if properly prepared, forms a useful food in famine times. It would also be profitable to feed it as part of the ration when fodder is scarce and prices high. Demonstrations might be given in other parts of the country subject to famine where this plant is found.

"(6) *The relative food values of Indian cattle foods.*—The Committee are of the opinion that a systematic investigation of the subject is desirable and should be best undertaken at Pusa, the necessary staff being entertained to carry out the work. In addition investigations should be conducted at the provincial farms to ascertain, by such methods as weight measurements, the relative feeding values of the different grasses grown in the provinces."

This report was accepted by a majority of the Board but, with reference to the investigation of the relative values of Indian cattle foods, the general feeling was that to be thorough this investigation must be strictly scientific (compare Kellner's work at Moeckern) and that it could only be carried out by a special staff with special equipment such as could not at present be justified by the comparative importance of the results likely to be obtained.

The difficulties in obtaining accurate results without most elaborate scientific detail and precautions were emphasised by such experienced officers as Col. Pease, Mr. Dobbs, and Mr. Wood, and it was felt that, while such general conclusions as those quoted by Mr. Clouston and Mr. Hamilton, *viz.*, the establishment of the value of a particular grass or of cotton seed and cake as a feeding stuff, might be arrived at by actual feeding tests: to be complete more scientific and elaborate tests, with apparatus of the kind used in Germany and America, would be required and that, at this stage

such elaborate and expensive investigation is hardly justified. At the same time there seems no reason why an analysis of the actual food constituents, *i.e.*, proteids, etc., of the various fodder and food crops of India should not be made either by all Agricultural Chemists or as a central piece of work by one Chemist. Apart from absolute scientific accuracy the information would be of considerable practical value. A beginning on these lines was made by Mr. Collins when Assistant Agricultural Chemist to the Government of India and it might well be extended.

In these notes the writer has done nothing more than attempt to put the interested public in possession of the latest information on the subject of fodder and feeding stuffs. It is hoped the impression left will be that amidst their many varied duties the Agricultural Departments are not forgetful of what they owe to the cattle of India on whose maintenance in health and strength the possibility of all agricultural achievement depends.

THE USE OF FISH AS CATTLE FOOD.

BY

R. CECIL WOOD, M.A.,

Principal, Agricultural College, Coimbatore.

DURING the closing months of last year, and the beginning of this, an experiment was conducted at the Central Farm, Coimbatore, to ascertain the possibility of using fish as a food for bovine stock, and ascertain what value, if any, this somewhat novel food had for the purpose.

The experiment was begun at the instance of Sir Frederick Nicholson, K.C.I.E., the Honorary Director of the Madras Fisheries Bureau, who suggested at first the use of *Fish Guano* as a cattle and poultry feed. His description of this was as follows:—

"It is the result of boiling good fresh whole sardine and nothing else; except the natural contents of the guts of the sardine (mostly removed in the boiling, etc., processes), there is no admixture of anything that is not tissue and bone of sound fish; there is no sand or foreign addition, as there generally is in the ordinary beach-dried 'fish-manure;' and it is absolutely free from taint and has been sterilised by steam boiling." At the same time Sir Frederick Nicholson suggested that it might be feasible to use ground *dried* fish for the purpose proposed, which, prepared as he was then preparing it, free from sand and absolutely without taint, would cost less than half the guano. Subsequently Sir Frederick Nicholson sent copies of various articles culled from the *Fishing Gazette* (New York), in which reference was made to the practice of utilising various fish products, guano, fish meal and so on, for cattle food in various parts of the world. It seems that in Shetland and Iceland

dry salt fish constitutes an important feed for cattle and sheep and even horses. It is not without interest to learn that in 1853, experiments carried on by Sir John B. Lawes at Rothamsted, on the feeding of pigs, included the trial of dried Newfoundland cod fish. The fish was fed with maize, barley, and bran, in different proportions, and Sir John Lawes reported that 'in these pens the pigs were very fat and well ripened,' and there was a very good proportion of increase to food consumed. He concludes 'this result is in itself interesting, and it may perhaps point to a comparatively greater efficiency in the already animalised protein compounds supplied in the cod fish than in those derived, as in the other cases, from the purely vegetable diets.'

Other references might be quoted, but it was soon clear that the feeding of such substances was not the absolute novelty it had at first appeared, and it was decided to undertake a definite test. Curiously enough, soon after receiving Sir Frederick Nicholson's letter, the writer heard of the practice of feeding mutton to special cattle kept for display of strength at village festivals in Nandyal, while it also seems a fairly common practice to make use of bandicoots when killed, by pounding them in a mortar and feeding them to cattle.

The first sample of dried fish, received from the Government Depôt at Tanur, was analysed by the Government Agricultural Chemist ; the figures are given below :—

Analysis of whole Fish.	Per cent.
Water	17·90
Insoluble mineral matter	2·48
Soluble mineral matter . ..	32·19
Oils and extractives ..	3·21
Crude proteids	40·75
Carbohydrates	3·47
	100·00
Containing—	
Albuminoids	30·10
Phosphoric anhydride (P_2O_5)	6·87
Potash (K_2O)	0·37
Lime (CaO)	[illegible]·78
Total Nitrogen	6·52

The samples actually used did not correspond exactly with this, and probably contained slightly more salt. They are described by Sir Frederick Nicholson as 'pilchardised.'

"The ungutted sardines are thrown into *brine*, or rough salted for a varying but short period, just as they come from the sea; they are then dried and are perfectly fit for consumption.

"The word 'pilchardised' is used because the Cornwall pilchards are salted ungutted. The samples were from several batches which had received slightly different methods of treatment."

The experiment was begun on the 5th of September under the instructions of Mr. Sampson, who was then acting as Principal and Superintendent of the Farm. Previous experiments conducted with working animals had shown that it was not easy to arrange for uniform work, and that the animals' live weights underwent wide variation at comparatively short intervals. Though it would perhaps have been more interesting to have noted the success of a fish diet on mature working animals, it was decided for experimental reasons to test it on young heifers. Ten were accordingly selected: ranging in age from 20 to 30 months and in weight from 316 to 508 lbs. The table below shows how they were divided:—

How Fed.	Number of Heifer.	Age in months.	Weight.	Monthly rate of increase.
Fish diet ..	55	28	476	17·0
	52	29	460	15·8
	58	27	428	15·8
	68	24	344	14·4
	53	29	352	12·1
Average	..	27·4	412	15·02
Ordinary diet	49	30	508	16·9
	62	26	352	13·5
	71	20	316	15·8
	51	30	432	14·1
	59	27	404	15·0
Average	..	26·6	402	15·12

These animals were, at the time of the experiment, on the following daily diet, so far as their concentrated food was concerned :

Cotton seed	..	..	½ lb.
Groundnut cake	..	..	½ „
Dholl husk (*Cajanus indicus*)			½ „
Salt ..	..	..	¼ tola

Analysis showed this to contain 0·329 lb. Albuminoids, 0·483 lb. Carbohydrates, and 0·122 lb. fat : disregarding the digestibility of the various substances, the albuminoid ratio works out to 1 : 2·3. In order to deviate as little as possible from this, the following ration was selected by Mr. Sampson :-

Rice bran	.	..	11 oz.
Dholl husk		.	½ lb.
Fish ..	.	..	¼ „

This gives the following figures :- Albuminoids 0·310 lb., Carbohydrates 0·517 lb., and fat 0·102 lb., with an Albuminoid ratio of 1 : 2·4.

The fish was ground in a disintegrator, and mixed in with the soaked bran and husk just before feeding, and the usual precautions were taken to introduce the animals gradually to the new diet.

The animals did not at first take kindly to the fish : they did not clean out their pans with the keenness shown by the animals on the ordinary diet, and it was not until the end of November, six weeks after the beginning of the experiment, that they ate it readily : since then, until the end of the experiment in the middle of March, no trouble occurred, and the animals seemed to find nothing distasteful in their diet.

So far as their health was concerned, the animals fed on fish kept perfectly healthy throughout the six months of the experiment, and no ill effects of any sort were noticed. Of the ten heifers, three on the fish diet, and only one on the ordinary diet, came into season and took the bull : it is insufficient evidence, but there certainly seems some reason to suppose that the fuller flavoured food had had some effect.

The live weights of the animals were taken weekly throughout the experiment. The best idea of the relative increase of the two lots may be obtained by taking the differences between the averages of the first three weighments and the last three weighments in each case. The figures are given below :—

Ordinary Diet.

Number of Heifer	62	49	51	59	74
Average of first three weighments	360	507	455	428	325
Average of last three weighments	439	592	478	523	396
Increase	79	85	23	95	71

Fish Diet.

Number of Heifer	53	55	52	58	68
Average of first three weighments	370	498	472	412	364
Average of last three weighments ..	421	561	533	435	435
Increase	51	63	61	23	71

The total average in each case may be obtained from these figures and is in the case of the fish diet just under 54 lbs. per head for the whole period, as against an average gain of 70 lbs. per head for the heifers fed in the ordinary way. The test seems a fair and conclusive one : the individual variation of the animals is evidently not excessive : each group contains one unthrifty animal whose exclusion does not alter the figures obtained above. It is clear that the fish diet is inferior to the other, to the extent shown by these figures. This inferiority may be termed a quantitative and not a qualitative one, since, as noted above, the animals fed on fish were perfectly healthy throughout. The question must accordingly be decided from the point of view of the relative cost of the two diets, and this will be largely affected by the locality, as the freight from the coast will have to be taken into consideration. Further, owing to the great fluctuations in the supply, it is not possible to strike an average figure to represent the cost of preparation. The following is quoted from

Sir Frederick Nicholson: "In South Malabar in 1912-13 there was hardly a single shoal of fat fish worth boiling for oil and 'guano,' while the small lean fish, running at from 70,000 to 100,000 per ton, were so numerous that the beaches were *covered* with 'fish manure,' the merchants' godowns were crammed, and I myself bought fresh fish at Rs. 3 per ton, which might mean below Rs. 20 per ton of dried fish as actual cost. This year, 1913-14, opened promisingly with fair quantities of fish, but for several months we have literally not seen a sardine, and my last purchases—months ago—were at Rs. 12 per ton, after which only a few baskets have been obtainable at any price. Hence I can give you *no* table or even approximate figures of 'cost.'"

The present trade value of dried fish, milled and *free from sand*, bagged and free on rail on the West Coast, is about Rs. 50 to 60 a ton, and this will probably rise as the value of the produce becomes more widely known, since Ceylon, the Straits Settlements, and Japan are already in the market for all classes of manure, besides the increasing local demand for both plains and hill cultivation. It is difficult therefore to say with any precision whether it is profitable to introduce it as a regular feed, but probably it is not. There is a slight difference in the cost of the two rations used in the experiment in favour of the fish (at Rs. 50 per ton delivered), but put alongside the smaller gain in live weight, there is nothing in it.

The general conclusions drawn are that no ill effects follow from the addition of fish to a mixed ration for cattle; and that after a little time no trouble is experienced in getting the cattle to eat it freely. So far as its fattening value is concerned, the fish does not compare favourably with groundnut. From a financial point of view, fish is not to be recommended for inland localities, though it is probable that on the Coast itself, in favourable seasons especially, a considerable saving might be effected by its use.

OPUNTIA ELATIOR, MILL. THE PRICKLY PEAR OF THE BOMBAY PRESIDENCY.

BY

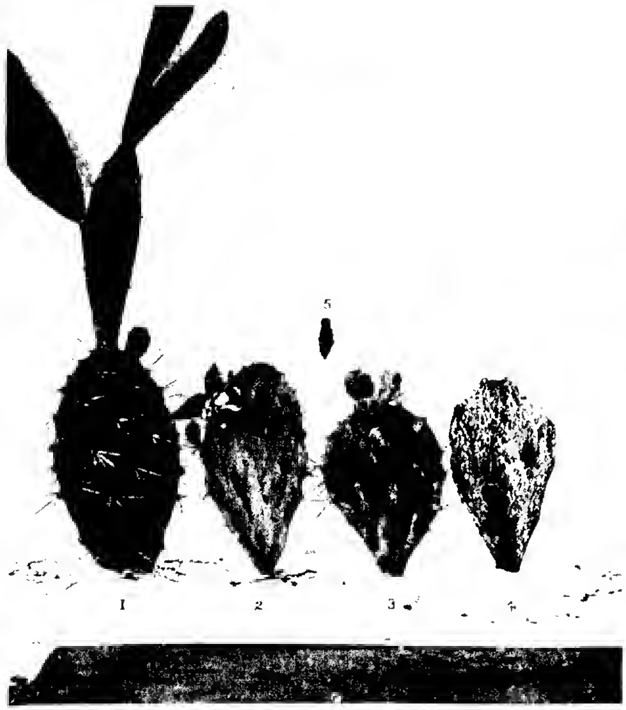
W. BURNS, D.Sc.,

Economic Botanist to the Government of Bombay.

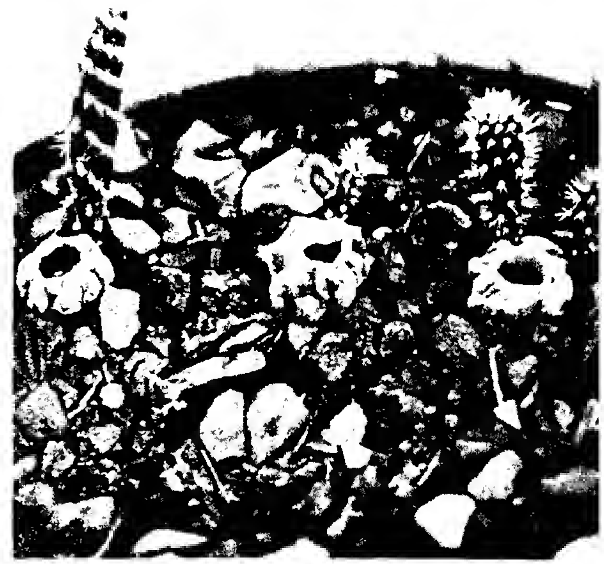
THE term "prickly pear" is commonly applied by English-speaking people to flat jointed members of the botanical genus *Opuntia*. The general term "prickly pear" has unfortunately been used, in work on the fodder value of the plant, without mention of the species. This is a source of confusion, since the species of *Opuntia* differ in their value as food for cattle, and in many other things of practical importance. One of the essential points, therefore, in reporting work on "prickly pear" is to know exactly the species dealt with.

This is by no means so easy a task as it looks, and there is still some disagreement as to the nomenclature of the *Opuntia* described in the present paper.

In Hooker's *Flora of British India* the only *Opuntia* mentioned is *Opuntia Dillenii*, Haw. In Cooke's *Flora of Bombay* mention is made of *Opuntia Dillenii*, Haw, and *Opuntia nigricans*, Haw, and the latter is referred to as having spread widely throughout the Deccan. The present writer was accustomed to use the name *Opuntia nigricans* for the Bombay prickly pear until the publication of Burkill's paper "Determination of the Prickly Pears now wild in India" (*Records of the Botanical Survey of India*, Vol. IV, No. 6, October 1911). In this, Cooke's *Opuntia nigricans* is determined as *Opuntia elatior*. The original paper should be referred to for



1. Joint producing roots and new joints. 2. Joint flowering.
3. Joint fruiting. 4. Fibrovascular skeleton of joint.
5. Closed flower.



Fruits producing vegetative growth

(*Opuntia elatior.*)

reasons of the change of nomenclature, to which the present iter will adhere. At the same time it should be mentioned that excellent coloured plate of *Opuntia nigricans* given in the *ricultural Gazette of New South Wales*, March 2. 1912, facing ge 210, is undoubtedly the plant called *Opuntia elatior* by rkill.

An individual plant varies from 6 to 10 feet high. The joints obovate in outline, and green. The size of the joints varies a od deal according to conditions of water and shade. They may ch the dimensions of 18″ long × 12″ broad, but the average in Deccan is 9″ × 5″. The thickness varies with the water-supply. the hot weather the joints are contracted and wrinkled, while the rains they are swollen and succulent. The fibro-vascular stem of a joint is shown in Plate XXXI. Fig. 4. This joint was turally skeletonised by the weather and it is a proof of the ughness of the fibre that the skeleton should be so perfect. e joints are very mucilaginous, have a large central water ring tissue and a many-layered epidermis, with calcium oxalate en in the outermost layer.

The sizes above-mentioned do not, however, apply to the first oot from the ground level. Whether this shoot comes from a dling or a cutting, the first joint is always exceedingly long in oportion to its breadth. Two actual cases measured gave the es 5″ × $\frac{3}{4}$″ and 13″ × $2\frac{1}{2}$″ respectively. This elongation may persist rough one or two succeeding joints as shown in Plate XXXI, g. 1. It is possible that it may be an adaptation to the necessity getting up to the light quickly. It must be mentioned, however, at the elongation occurs in the first joints of plants in exposed uations, so that it is now a fixed character and independent the light conditions in the environment.

Plate XXXII. Figs. 1—4 show the groups of spines when young d when mature. In the mature joints the spine groups are $1\frac{1}{4}$″ to apart in quincuncial fashion, except at the edges, where they are owded, especially near the apex. In the young joint the luced body (*b*) which represents the leaf may be seen under ch spine group. This falls off before the joint is full sized.

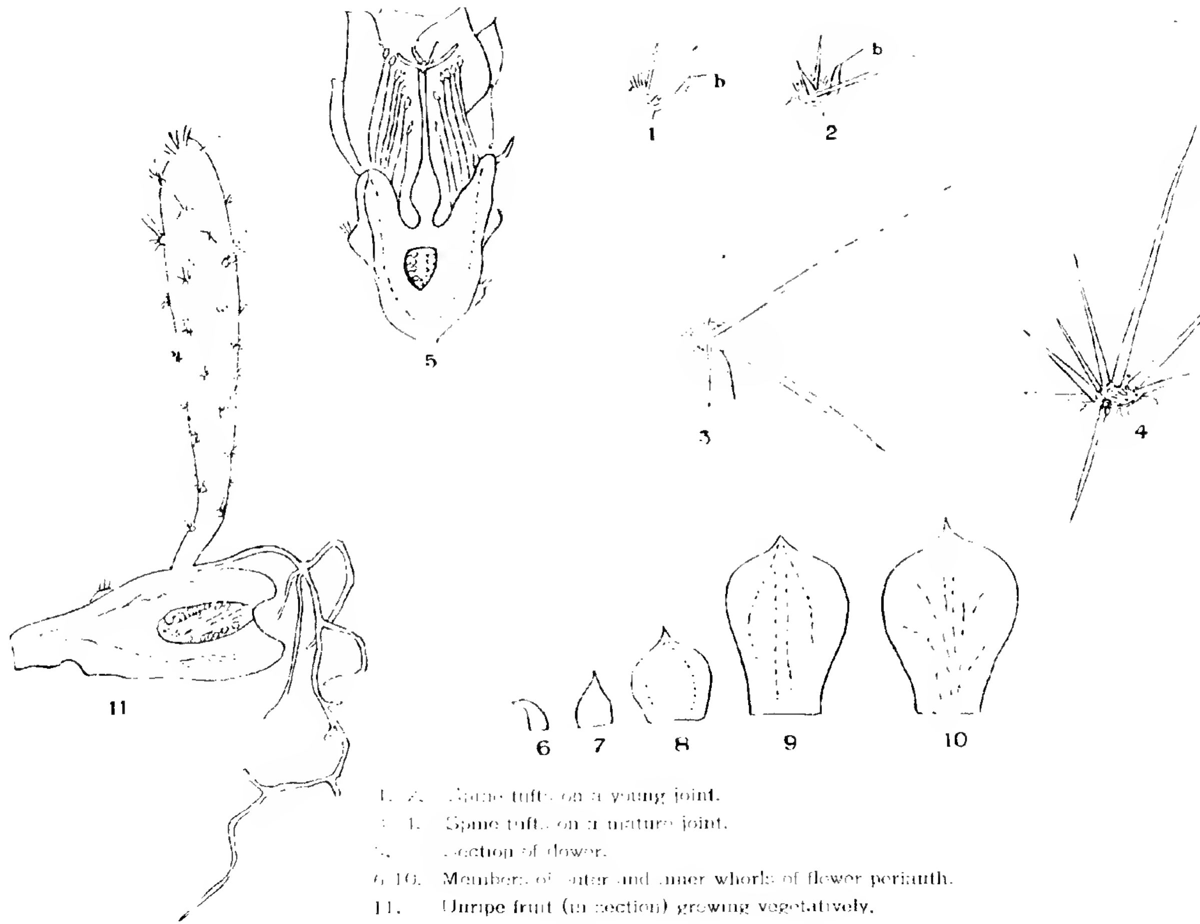
At the base of the large spines is a cushion of small, tawny, very irritating yellow spines. The larger spines vary in number and size, but one is often somewhat larger than the rest. Plate XXXII, Figs. 3 and 4, show the natural size of these. They are usually tawny with black bars when ripe, but may also be pure black.

Branching takes place from the exact apex of each joint and also from the edge of the joint, just below the apex. There is a tendency for the joint at the apex to be at right angles to the joint below, while the joints from below the apex are usually in the same plane as the joint from which they spring. One can easily see that this arrangement will on the whole tend to increase the stability of the plant. As the plant gets older the basal joints of the plant become round and are covered with dead grey bark.

The flowers (Plate XXXI, Fig. 2) are borne on the edges near the tops of the last-formed shoots. The main flowering season is in July and August among plants near Poona. The flower is shown in section in Plate XXXII, Fig. 5. The ovary is deeply sunk in a green fleshy torus protected by spines of the same type as those on the joints, but smaller, and with the tufts more closely together. There is no distinct calyx and corolla. Plate XXXII, Figs. 6–10, show the gradual transition from a small thick bract to the membranous inner "petals" of the flower. The relative position and ripeness of stamens and stigma show that self-fertilisation is probable. The "petals" close up later on (Plate XXXI, Fig. 5), and the "petals," stamens, style, and stigma finally fall off leaving the still green young fruit behind (Plate XXXI, Fig. 3). This becomes deep crimson when ripe and the inside is edible. Burkill, in the paper previously cited, distinguishes thus between *Opuntia nigricans* and *Opuntia elatior*:

Flowers orange	*Opuntia nigricans*
Flowers at opening lemon-yellow changing to rose pink ...	*Opuntia elatior*

The colour of the "petals" undoubtedly changes to rose pink and hence it may be assumed that the name *Opuntia elatior* is correct.



1, 2. Spine tufts on a young joint.
3, 4. Spine tufts on a mature joint.
5. Section of flower.
6, 10. Members of outer and inner whorls of flower perianth.
11. Unripe fruit (in section) growing vegetatively.

The propagation of this plant is effected in various ways. Seedlings are produced but are rarely observed. The two cotyledons are thick, fleshy, green and *absolutely spineless.* They soon fall off and the plant then proceeds to develop its long underground roots and elongated first joint.

Propagation from severed joints is often seen. Such joints have an extraordinary vitality. They may have lost all their greenness and yet remain succulent and ready to produce roots. In May 1913, on the land of the Agricultural College Farm, Poona, some *Opuntia elatior* was cut down to the ground, uprooted, burned on the spot, and the rubbish carted away. In May 1914 some of the joints which had escaped complete destruction were giving out new joints and had established roots in the soil. Such roots develop from the sites of the spine tufts. Even when a cut is made across a joint and the cut end inserted in soil, the roots come from the sites of the spine tufts below soil and not from the healed cut. Plate XXXI, Fig. 1, shows the result of such an experiment. The cut joint was planted in a pot in June 1913 and photographed in June 1914. It had made a few long straggling roots and the joints above itself. A method of propagation which the writer has repeatedly observed is represented in the second photograph in Plate XXXI, where an unripe fruit planted in the soil develops vegetatively from one of the spine tufts just as if it had been an ordinary joint. Plate XXXII, Fig. 11, shows a section through such a fruit demonstrating that there is no connection whatever between the plant produced and the unripe seeds in the ovary.

The root-system of the plant as it is found in the field is extensive. Roots have been traced to 6 feet away from the centre and 3 feet deep. The roots are exceedingly tough, and contain crystals of calcium oxalate in considerable quantity.

When one takes into consideration all the advantages and protective qualities possessed by this plant, and in addition its extraordinary power of vegetative propagation, it is not to be wondered at that it is difficult to *completely* eradicate it where once it has become well established.

TURF.

BY

C. M. HUTCHINSON, M.A.E.B.,

Imperial Agricultural Bacteriologist

THE successful growth of turf depends in India, as it does in Europe, upon the selection of those grasses most suited to the local conditions of soil and climate and the purpose for which the turf is required. In England a mixture of several kinds is generally used, whereas in India, at least in a very large number of places, the production of a pure culture of *doob* (*Cynodon dactylon*) is most commonly aimed at, and this for various reasons, mostly good ones. *Doob* is easy to grow, and with proper treatment gives a good surface for golf or tennis; it is not a good grass for polo grounds, being slippery and treacherous and requiring more care and attention than most polo clubs can afford to apply to twelve acres of turf. It is liable to form thick mats of growth in some spots and to die out in others owing to inability to compete with other deeper rooted grasses in the dry season, either for food or water. This disability can be overcome on the small scale required for tennis courts and putting greens, but twelve acres of polo ground is a large area to water manure, and hand weed. The same remark applies to cricket grounds, and in addition it may be pointed out that a *doob* wicket-table requires special preparation, entirely different from that of the outfield, generally involving the use of clay. For the outfield of a cricket ground, for polo, and even for hard-worked tennis courts nothing is better than a judicious mixture of coarse grasses, but the trouble lies in proper selection, if the condition of the soil and climate is not such as to produce a natural mixture which cutting, rolling,

sanding, and manuring will turn into a good composite turf. Such a mixture will stand much more hard work and resist drought better than a pure *doob*, and many coarse grass tennis courts have as good a playing surface as any made of *doob* alone.

Nevertheless *doob* is so much more easy to grow, and the use of one well-known grass instead of a mixture containing individuals whose habits and requirements are not so familiar, simplifies its treatment. The intention of this article is to describe the writer's experience of making *doob* turf at Pusa in the hope that the methods adopted may be found of use elsewhere. It should be stated, however, that the writer's experience of the use of ammonium sulphate for this purpose has been limited to this particular soil, and although the general principle of treatment remains the same for any soil on which it is desired to grow *doob*, yet it may be necessary in other localities to include lime or basic slag in the application, this not being necessary at Pusa owing to the large quantity of the former already present in the soil.*

The ordinary practice adopted for making a *doob* lawn is to remove the surface growth entirely, plough or hoe the soil itself, remove grass roots, and dry out weeds by exposure to the sun. The surface is then levelled and plastered over with a mixture of mud and cowdung in which the *doob* is planted. This method produces a *doob* lawn in a remarkably short time, but it has disadvantages, amongst which may be reckoned the following:—

(1) The use of cowdung reintroduces an enormous number of weed seeds which germinate later and make constant weeding necessary.

(2) The mud plaster generally used produces a surface which dries hard and cakes when rolled and when the sun gets on it; such a surface is prejudicial to vigorous plant growth and especially bad for turf.

It has been found better, in this method of making a lawn, to replace the cowdung by using either oil-cake or sterilised animal

* If lime is required it must on no account be applied at the same time as the sulphate of ammonia, but should be put on not less than two months later.—C. M. H.

meal, the latter being a preparation of slaughter house refuse obtainable from Calcutta and containing about 8% nitrogen. Oil cake, if fresh, should be kept for at least six months before use, and finely powdered before application.

In cases where it is required to make a tennis court or putting greens out of grass land, or to improve the condition of already existing ones the method hereinafter described has been found successful; it must be stated, however, that success has depended upon the presence of a certain proportion of *doob* amongst the other grasses present, and although the use of ammonium sulphate and sand in the manner prescribed has been eminently successful at Pusa both for maintaining the condition of putting greens laid down with pure *doob* from the start and for creating *doob* greens out of the mixed turf grasses normally found there, this method applies more particularly to the latter condition and has been worked out with special reference to it; the writer's object in carrying out the experiments on renovation of turf was mainly in connection with the use of the latter as a standard crop for measurement of the relative manurial value of various agricultural operations depending upon bacterial action; perennial turf grasses respond rapidly to applications of available nitrogen and the obvious and rapid character of this response makes it possible to use them as qualitative indicators of the presence of nitrogen in this condition. Thus the difference between the relative availabilities of nitrogen as sodium nitrate and ammonium sulphate can be seen at a glance when these are applied to a *doob* plot, as a darkening of colour which may occur in the case of sodium nitrate within 24 hours and in that of ammonium sulphate generally a day later at the earliest.

Doob is a shallow rooted plant and obtains its food from the surface layer of soil; most of the other grasses, with which it has to compete, such as *motha* (*Cyperus rotundus*), *dabhi* (*Imperata arundinacea*) and *rari* (*Saccharum spontaneum*) are comparatively deep-rooted; now the keenness of competition between plants growing close together, as turf grasses do, is very great, and the ultimate survival of individual kinds is determined by quite small initial differences in their relative power of obtaining either

food or water. Taking a mixture therefore of deep and shallow rooted grasses, and supplying plant-food which tends to remain near the surface or to undergo only near the surface such changes as are necessary to make it easily assimilable by plant roots, the result will be the gradually increasing growth of the shallow rooted plants and a corresponding diminution in that of the deeper rooted kinds. Experiment has shown that nitrogen is the chief requirement of the *doob* grass plant and indeed this grass responds so quickly to nitrogenous manures that it is possible in many cases to produce a good growth of it simply by heavy dressings of such materials as oil cake or cattle manure, but the results are not so certain nor the character of the growth so good as may be obtained by the use of ammonium sulphate. It is a fact, well-known to agricultural chemists that salts of ammonia, such as ammonium sulphate, are retained by the soil to which they are applied, whereas another nitrogen-containing compound, nitrate of soda, is easily washed down through it by rain: thus an application of nitrogen in the form of sulphate of ammonia will tend to remain near the surface whereas one of nitrate of soda will tend to move downwards. This is the underlying principle suggesting the use of sulphate of ammonia for encouraging the growth of *doob* at the expense of other deeper rooted grasses. In practice, it has been found at Pusa that the application of sulphate of ammonia to very bad turf containing in addition to *doob*, *motha*, *dabhi*, *rari*, *apang* (*Andropogon annulatus*), *tetar* (*Launea asplenifolia*), and *dudhi* (*Euphorbia thymifolia*) results in the eventual elimination of everything except the *doob*. This result was obtained in the cold weather beginning in November, when, owing to comparatively low temperatures and scarcity of soil moisture, the competition between individuals would be keener than during the rains, thus allowing the treatment to have full effect. It is not certain that the method would be equally successful during the rains, although the use of sulphate of ammonia at the latter time of year produces a vigorous fresh growth of *doob* on putting greens and tennis courts already possessing a fair proportion of this grass.

In the first experiment carried out, beginning on 5th November 1913, a piece of very bad ground which had never been planted with *doob*, was cut and rolled and divided into eight plots measuring 10 feet × 10 feet each. These were treated as follows :—

A and A1 sulphate of ammonia and superphosphate ;

B and B1 sulphate of ammonia alone ;

C and C1 no manure ;

D and D1 sterilized animal meal :

A1, B1, C1, and D1 were also covered with a thick layer of coarse sand.

The amounts applied calculated per 100 sq. feet were as follows :—

Ammonium sulphate 3·5 lbs. Superphosphate 8 lbs.
Sterilized meal 3 lbs.

The ammonium sulphate was dissolved in water and applied with a watering pot, the amount used being ammonium sulphate 3·5 lbs. in 4 gallons of water to each 100 square feet of turf.

Thus for a tennis court 78 × 36 feet 98 lbs. of ammonium sulphate would be required. Before treatment the ground showed patches of bare soil with scanty growth of poorly nourished plants of *dabhi*, *motha*, *apang*, and *doob* with some *rari*, *tetar*, and *dudhi* ; in 48 hours after treatment all these plants, including the *doob*, appeared to be dead, being brown and burnt ; two days later fresh green shoots of *doob* were found which gradually covered the bare patches, and in one month's time, with no further treatment except daily watering and periodic cutting, the whole surface was covered with a nearly pure culture of *doob*. This was in the case of ammonium sulphate alone or with sand ; where superphosphate had been added but no sand, a bad blackening of the soil with no growth occurred in patches ; this had been prevented by the addition of sand, but in both the superphosphate plots, although eventually covered with a thick growth of grass, this was not pure *doob* but contained many plants of *apang*, *dabhi*, and some *motha*, which seemed to be sufficiently strengthened by the phosphate to stand competition with the surrounding *doob*.

The sterilised meal plots were very promising at first, especially the sanded one, which after six weeks' growth (in November and December) compared favourably in appearance with the ammonium sulphate plot. Examination however showed that a large number of plants of *apang* and *dabhi* were present and after eight weeks the whole plot began to lose colour and develop patchiness due to failure of the *apang* and *dabhi* to make equal growth with the *doob*. The result was unexpected as it was supposed that the sterilised meal would supply nitrogen slowly and regularly by nitrification of its organic nitrogen content and that this supply would consequently continue for a much longer period than would be the case with ammonium sulphate: the plots to which the latter was applied, however, showed no signs of falling off in colour or condition until the middle of January when it was found that some plants of *motha* had appeared: a fresh application of ammonium sulphate was made which effectually eliminated these intruders, and from that date until the time of writing (15th June) nothing but *doob* has grown on these plots, the growth however being perfectly even and close and of dark green colour, and in the case of the sanded plots the surface is hard with no loose matted growth. It would of course have been perfectly easy to have handweeded these plots to remove the intrusive *motha*, but it seemed better to ascertain whether manurial treatment alone could obtain the same result.

The deterioration of the sterilised meal plot was thought to be due to failure in the nitrogen supply and the immediate recovery, visible within 48 hours time, resulting from an application of ammonium sulphate, seemed to prove this conclusively. A further result of the additional treatment has been the rapid extinction of the surviving deep rooted grasses.

It will be seen that this rate of application of ammonium sulphate is an extremely high one as compared with agricultural practice, and is proportionately expensive, the present cost of ammonium sulphate being about Rs. 14 per cwt., but in dealing with such small areas as tennis courts and putting greens this consideration would usually fade into insignificance by comparison with the excellence of the results. It should be emphasized, however, that it would

generally be useless to attempt economy in the use of this treatment as unless enough of the ammonium sulphate is applied the elimination of weeds aimed at will not be obtained.

So far as current expenditure is concerned it is not possible at present to say at what intervals of time it may be necessary to renew the treatment, but so far as experience at Pusa has gone, it does not seem likely that application of ammonium sulphate will be required more than twice in the year and that not at the original rate but at half this quantity, *i.e.*, 1¾lbs. in 4 gallons to 100 square feet, say 50lbs. for one tennis court. The necessity for such application can be easily judged by noting the colour of the grass, which should never be allowed to become pale green or yellowish: should this occur, one application will within 48 hours bring it back to the proper colour. In cases where the presence of an unduly large number or more vigorous growth of weeds occurs it has been found better to apply the ammonium sulphate, at the rate of 3½lbs. to the 100 square feet, in the solid form, sowing it over the ground as evenly as possible and then watering it in with the amount of water (4 gallons) prescribed. The effect is more marked so far as destruction of the weeds is concerned, and might probably be arrived at simply by dissolving the salt in say 3 gallons of water instead of in 4 gallons. It is perhaps advisable here to point out the necessity for avoiding the use of too much water which would destroy the effectiveness of the salt by dilution, and the deleterious effects of irrigating lawns by periodic flooding, which does an immense amount of harm, especially by reducing nitrates and washing down available plant-food from the surface layer where it is wanted by the *doob* to lower levels where it will help the deeper rooted weeds to compete with the former. All water should be applied in small quantities at frequent intervals; every evening during the cold and in the dry hot weather, and during breaks in the rain so soon as drought is indicated by the condition of the grass. The actual amount required is small, just sufficient to moisten the top inch or two in which the *doob* roots are growing.

It was thought that during the drought of the cold weather the deeper rooted plants would have an advantage with regard to

water-supply, but this has not proved to be the case; the probable reasons for this result are discussed in dealing with the use of sand.

It is perhaps unnecessary to point out that no success will be obtained in growing turf of any kind on waterlogged or sour soil, where an inspection of the grasses will show that nothing but poor acid loving weeds can flourish. On the other hand, the deleterious influence of trees, and more especially of bamboos, is in most cases directly due to their action in absorbing soil water at the expense of the shallow rooted grasses and other plants in their vicinity; this action can be greatly mitigated by cutting deep trenches so as to separate the grass area from the root system of the neighbouring trees, the roots of which must be cut by the trench; care must be taken subsequently to see that fresh tree roots do not grow through the trench as is liable to occur.

Sand.—The soil at Pusa, although of a light sandy character, shrinks on drying, forming a surface crust which interferes with plant growth in various ways, particularly by diminishing the free and even penetration of the soil by water and air, and also by actual mechanical interference with the growth of stems and surface roots such as are formed by *doob* grass, maize, oats, and other plants. In field practice this tendency necessitates surface cultivation, and in the culture of pot plants in the laboratories at Pusa as much as 30 per cent. of sand is added to the soil to prevent the shrinking and cracking of the latter. It has been found by experiment that sand has an advantageous effect on the growth of *doob* grass such as it might have been expected to produce from a knowledge of the above facts in connection with Pusa soil; it may be stated at once that on soils with any tendencies of the above described character the use of sand is of almost equal importance with that of ammonium sulphate; *doob* turf can indeed be grown on almost any soil if provided with a sufficiency of nitrogen, but on any of the numerous soils which tend to form a surface crust on drying from a wet condition, it is only by the use of sand that a truly even growth affording a surface, which can be made true by hard rolling and close cutting, can be obtained. The sand combined with a close growth of *doob* roots and stems produces a surface which can be

rolled smooth and hard, however wet it may be, without puddling or forming a crust, the sand moreover provides a surface "mulch" of coarse particles which not only break up and distribute water supplied either artificially or as rain, but prevent drying out of the surface soil during the dry season of the year. It is a remarkable fact that at Pusa the mere application of an inch of river sand to a piece of poor turf resulted in a great improvement not only in the growth of the grasses, but in the general condition of the turf itself by the elimination of the bad weeds. In an experiment in which oil-cake was used by itself and in conjunction with ammonium sulphate a very marked improvement was effected in both cases by a cross dressing of sand, especially in the latter combination. In actual practice the sand does not remain above the soil and separate from it for any length of time, but becomes incorporated with the surface layer, thus rendering it more open in texture and pervious to air, water, and root growth, and it undoubtedly promotes the more rapid nitrification of either oil-cake or ammonium sulphate both by the aeration and even water distribution which it ensures. It will be remembered that the selective action of ammonium sulphate as compared with that of sodium nitrate, in encouraging surface rooting plants, was attributed to its retention near the surface: the change into nitrate which is probably necessary to make it available as plant-food will also be promoted by the aeration afforded by the added sand, also near the surface and therefore more readily obtained by the shallow feeding *doob*. The gradual lowering in concentration of the surface layer of sand by mixture with the soil makes it advisable to repeat the sand application whenever the surface begins to become soft owing to the increasing thickness of the growth of *doob*; in some cases where, owing to richness of the soil, an unduly thick and soft growth of *doob* has formed (as was the case on and around some of the greens, notably the 12th on the newer part of the Tollygunge golf course) a thick dressing of sand will fill up and harden the turf and allow of the formation of a hard true surface which can be rolled hard and cut close without injury. The most important point in connection with the use of sand is the quality of the latter. It is quite easy to mistake silt

for sand, or to use sand which may be so fine as not to possess the mechanical properties requisite for success. It is difficult to give directions for distinguishing one from the other, but generally speaking it may be said that sand if put in water will sink to the bottom and leave little or no cloudy floating particles and that coarse sand has a very distinct gritty feeling between the fingers. It is of the utmost importance, however, that the material employed should be sand, *i.e.*, particles of quartz, and not silt, which may be a mixture of materials such as felspar, which in course of time will disintegrate to form clay and so produce a worse condition in the surface soil than it may have originally possessed. Building sand, known as "sharp" sand, generally possesses the desirable mechanical properties above described, but it is usually possible to find deposits or pockets of coarse sand in almost any locality. Such sand if thoroughly wetted and compacted should on drying show no tendency to hold together but should fall apart at a touch. As mentioned above, the amount of sand used at Pusa was about 150 lbs. to 100 square feet; for a tennis court this would require about 56 maunds or some 5 cartloads; when first applied most of the grass will be completely buried: the surface should then be rolled smooth and watered with the solution of ammonium sulphate, care being taken to obtain an even distribution of the latter. The ground should be marked out in squares of equal size, the salt weighed out into portions each sufficient for one square and dissolved in the appropriate amounts of water; kerosene oil tins holding 4 gallons can conveniently be used to dissolve $3\frac{1}{2}$ lbs. of the ammonium sulphate, which will then be watered, by a watering pot with a rose, on to one 10 feet × 10 feet square. This can more easily be done by marking out an area 80 feet × 40 feet so as to allow of a margin to a tennis court.

A series of small plots was laid out in which pure cultures of *apang, motha, dabhi, jor* (*Rottboellia sp.*), and *rari* were grown separately in order to observe the effect of varying treatment upon them individually, and to arrive at a more accurate notion of the causes underlying their gradual extinction by treatment resulting in the ultimate production of *doob* turf. These have only been under observation for a few weeks at present, but the addition of sand

has already caused a marked retardation in the growth of all the above mentioned grasses as will be seen from Plate XXXIII. It is not at all clear why this should be so although various conjectures might be hazarded, but the fact remains that sand has a positively prejudicial effect on these undesirables, so far as observation at Pusa has gone, whereas the growth of *doob* is favourably affected.

So far as sand is concerned, therefore, the writer is of opinion that its value for making turf is undoubtedly high for the following reasons :—

(1) It encourages the growth of *doob* and discourages most of the undesirable grasses.

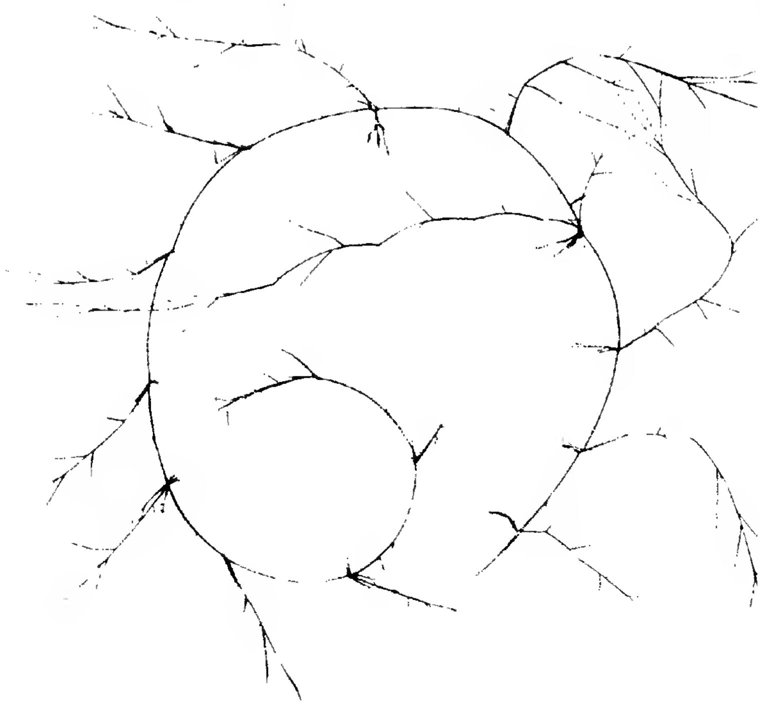
(2) It improves the water-supply, both during the dry season by forming a surface mulch, and during the rains by preventing puddling of the surface and causing even distribution.

(3) It improves the playing qualities of the turf by filling up inequalities, preventing too luxuriant or matted growth of *doob*, and allows of the production of a firm surface by rolling, without the formation of a surface crust.

The method above described of producing *doob* turf depends upon first destroying as much as possible of the undesirable weed growth by heavy dressings of sulphate of ammonia and then upon keeping the surviving *doob* in condition by means of the liberal nitrogen supply thus provided and by the use of sand. The quantities given are those which have proved successful at Pusa, during the dry season, but any reader who wishes to make use of the method is strongly recommended to make his own experimental plots in order to determine the quantities appropriate to the particular soil of his own district. The plots can be quite small, a few feet square, and the quantities varied from half to double that recommended; the sand, however, must be kept up to the amount necessary to cover the surface to a depth of at least one inch. Other alternatives to ammonium sulphate have been tried at Pusa as possibly more readily obtainable, and if used in sufficient quantity and in conjunction with sand have been found successful although not to the same degree, but they were not so easily applied nor was the result so lasting. Sterilised meal has been referred to and the quantity

PLATE XXXIII.

Effect of sand on turf weeds. Left side, sand. Right side, no sand.



Roots of "Doob" (*C. dactylon.*)

used mentioned ; oil cake was also tried successfully, but was much improved by subsequent dressings of ammonium sulphate ; one other method which promises well is now under observation and may be mentioned here as possibly providing a sufficient nitrogenous dressing at only the cost of the labour involved in collecting and applying the material.

The cut grass from a lawn if allowed to lie and not caught in the box on the mowing machine, remains on the surface, where various fates may overtake it : generally it dries up and gradually falls to powder which resists further decay for considerable periods and merely attracts the attention of insects which feed on it and sometimes turn their attention to the cut ends of the growing *doob* to the great detriment of the latter ; otherwise it may simply blow away as dust or during the rains be washed into unsightly streaks and patches, which then remain moist long enough to ferment and "burn" the *doob* ; this is quite a common effect on lawns mown without a grass box. In either case the manurial effect sometimes attributed to this untidy method does not appear to occur in actual practice. If the cut grass is soaked in water for about a week, the watery extract thus prepared will be found on analysis to contain considerable quantities of ammonia, owing to the fact that the unavailable nitrogen contained in the grass has been brought into this form by such bacterial action as occurs under these conditions ; this ammonia when applied to the soil will perform the same function as sulphate of ammonia although in a different manner, as the browning of the grass plants which is the first visible effect is due to direct poisoning of the latter and not merely to interference with their water requirements by the production of the condition known as "physiological dryness," such as results from the application of sulphate of ammonia. When the *doob* has been established by the use of this grass water, further applications should be considerably diluted and allowed to stand exposed to the air for some days in order to destroy the toxins formed during fermentation which are responsible for the burning effect on the grass. The effects of applications of this extract are not so lasting as those of sulphate of ammonia as they do not contain so much nitrogen in one application.

but it will be obvious that it is only necessary to repeat them at the proper intervals in order to maintain the necessary supply of nitrogen. It will perhaps make the matter clearer if it is pointed out that *doob*, as above-mentioned, depends upon a liberal supply of easily assimilable nitrogen, and that the ordinary processes of decay of organic matter in the soil do not as a rule provide this with sufficient rapidity nor near enough to the surface; for the same reason cut grass left lying will fail to supply nitrogen because it tends to decay in such a manner that its nitrogen remains inert; if however it is brought under the conditions above described the special bacterial action involved will ensure the inclusion of the nitrogen it contains in the process of decay, with the result that this necessary element is brought into an available condition at a rapid rate.

It is unfortunate that the grass water thus prepared possesses a characteristic odour which is not altogether desirable; this may be mitigated by exposure to the air, and when the water is to be used in conjunction with sand the latter may be made into a heap and watered with the extract previous to application; this will reduce the odour considerably. Experiments are in progress to determine a method of destroying it altogether without loss of ammonia: a solution of permanganate of potash is the simplest and most effectual means so far discovered. It may be mentioned that the decomposing grass continues to give up ammonia for a considerable period, so that several fresh water extracts can be made from the same material. The remaining decomposed grass itself may be advantageously used in place of cattle manure in the garden.

Although experience has shown that the artificial supply of nitrogen will suffice to produce a luxuriant growth of *doob* on a soil which without this addition appears too poor to carry it, it must be remembered that this crop, like all others, requires in addition such elements as phosphorus, potash, and lime; some soils may be so poor that no amount of nitrogen alone will produce growth, and in such cases it will be necessary to use a more complete manure, and indeed in any case the luxuriant crop produced by the use of ammonium sulphate will eventually deplete the soil and make it necessary to restore the loss. This might be done so far as phos-

phate, potash and lime, are concerned by the method of leaving the cut grass lying on the surface, but, as has already been pointed out, the manurial action of such treatment is irregular and the nitrogenous portion does not come into full use. Two methods may be adopted; in one the original laying of the lawn will include the importation of good soil to form a basis for growth; in the other the use of such a manure as sterilized animal meal or oil-cake will provide the necessary phosphates together with nitrogen. The selection of method will depend naturally upon local conditions. In the case of the animal meal this manure contains a high percentage of nitrogen and phosphates and has given excellent results as detailed above. On the other hand, a 4-inch layer of good loam in conjunction with a top dressing of sand and sulphate of ammonia has produced equally good results although with less rapidity.

Cricket Grounds.- As above pointed out different treatment is required for the preparation of the wicket-table and of the out field. In the former for instance the use of sand is not permissible as this produces a wicket which rapidly goes to pieces and becomes dangerous: in this case if the soil is light and sandy, it is necessary to import a heavier variety of soil which will roll out into a good wicket; *doob* can be grown on this by application of ammonium sulphate and careful handweeding, and as it will only be used in the cold weather, much less trouble will be experienced in keeping it in condition than would be required during the rains: this refers to the use of a heavy soil upon which *doob* will not do well if cutting and rolling are carried out to any extent in wet weather. It must be remembered, however, that a cricket pitch requires only a minimum of grass, just sufficient to keep the surface together but not enough to produce a dead wicket. Where a wicket-table has been built up by importing soil, it will often be found that the grasses deteriorate after a few seasons owing to the appearance of weeds such as *motha* and *dabhi*: this generally means that the immediate surface layer upon which the *doob* depends for food has become depleted either of nitrogen, or phosphates, potash and lime, or sometimes of all four: the first of these is generally the limiting factor, but when ammonium sulphate fails to produce a response it is in consequence of depletion

of one or all of the last three. A general manuring is then indicated, but if the condition of affairs is really bad it would be better to plough up the affected area at the beginning of the hot weather in order to get rid of the weeds and their roots by drying them out. Otherwise a dressing of sterilized animal meal at the rate of 10lbs. to 100 square feet will be found effective, or, if the deterioration is taken at an early stage, a simple dressing of good loam soil, dried and sifted, will carry on the growth of *doob*, although it may be necessary to supplement it with sulphate of ammonia within a few weeks of application.

Cutting and Rolling.—It is a matter of common knowledge that good turf can be produced in time simply by judicious cutting and rolling of a mixture of good and bad grasses, provided that moisture and soil conditions are sufficiently good to support growth. The selective action of these two operations, so far as *doob* and other grasses are concerned, appears to depend upon the following points. Repeated cutting close to the ground puts a strain upon the coarse grasses by making it necessary for them continually to produce fresh leaves to take the place of those removed; a similar strain falls upon the *doob* but owing to its habit of growth, which is close to the ground, the mowing machine removes a much smaller proportion of leaf, and the adventitious roots which occur at frequent intervals along the stem help to provide nourishment and water to every part of the plant and make it independent of the main root from which it started growth. In the same way other fine-leaved grasses will survive cutting which is too close for the coarser kinds, this action being largely responsible for the production of turf where other grasses than *doob* are concerned. Cutting may be regarded as a form of pruning the grass plant and has the effect of stimulating growth indirectly and altering its character and the shape of the plant itself, the general effect being the production of a larger number of leaves and stems over the same area of ground and consequently a thicker and closer turf. It is therefore of great importance that this operation should be carried out systematically and with judgment, both with regard to the height of the cut above the ground and the frequency of cutting. With reference to the latter point it

should be observed that too long intervals between cuttings, especially with lawns formed of other grasses than *doob*, can ruin turf more surely than almost any other method ; the immediate result of such unduly long intervals is to allow the formation of stems and leaves which are not only long but thick, these when cut remaining as stubble amongst the surrounding growth and giving occasion for more regrettable expressions upon the putting green than any other agency outside the match. Good turf must be cut before it gets to this stage, and at the same time must be provided with the extra nutriment required by the increased growth resulting from the stimulus of cutting.

It will be seen that cutting means more than simply preventing the grass from getting too long, and for this reason it is important to make use of an efficient machine, which will not only cut as close as may be found necessary, but will withstand the efforts of the *mali* to bring about its disruption. Cheap machines have defects which in the writer's opinion more than counterbalance their cheapness, and where it is desired to cut comparatively small areas of turf and at the same time to produce a good playing surface they cannot compete with high class machines. If it is merely a question of keeping down jungle and giving a general impression of upkeep by haggling off the ends of the grass with blunt ill-adjusted cutters, then cheap machines are as good as more expensive ones, but owing to various defects in material and design inseparable from their lower price, it is impossible to keep them in first class cutting condition, nor can they, even when new, cut as close or even as a good machine : this is a question of gear ratio, and number of knives in the revolving cutter, which varies from three in cheap machines to six in good makes, just as the wearing is one of accurate machining of the gears and of the material used in them and in the bearings. The point to be remembered is that judgment must be exercised in setting the height of the cutter-bar above the ground so that the requisite amount of grass may be cut, but that this will be wasted if the machine used cuts unevenly, or if the cut is not clean either on account of a too low gear ratio or because the cutter-bar or knives are not properly set, so that the grass is half pinched and half pulled off ; this has a very bad effect on *doob* especially during dry weather as the pull

destroys the attachment of many young adventitious roots to the ground and leaves them to dry up; this effect can be seen quite easily on examination of turf cut with a blunt slow-running mower. The best size of machine to employ for small areas depends upon the character of the surface; if this is dead level, as on a tennis court, the use of a comparatively long cut, such as 20 inches, will cover the required area in less time and with equally good results: but on putting greens where hollows and small curves may occur, a 12-inch cut will be found more suitable; the larger machine has an advantage in weight, inasmuch as it will run nearer the ground and also perform the function of a roller; on the other hand, during wet weather, a light machine may be used with impunity when a heavier one may damage the surface: a sufficiency of sand will, however, minimise this drawback. With regard to rolling it may be pointed out that on a *doob* lawn one of the functions of the roller is to bring the *doob* stems into sufficiently close contact with the ground to promote the formation of adventitious roots at frequent intervals.

It should be unnecessary to point out the fatal effects of either rolling or cutting turf when the latter is too wet; the obvious results of such action are rapid deterioration in the quality of the growth, frequently accompanied by discoloration and death of the grass plants: the extent to which these effects will follow depending upon the character of the soil and the amount of moisture present at the time. It does not require much knowledge of the conditions of growth to enable one to understand how this comes about, as it is obvious that the weight of the roller or mower will puddle the soil surface if wet enough, and probably bury the growing points of the grass; at the same time the puddling will result in the formation of a hard impervious crust which will choke the plants.

A word of warning may be given with reference to worm-killers; which are frequently used without any consideration of their effect upon the turf grasses, or of the fact that the destruction of earthworms may save trouble for the green keeper, but at the same time removes the only means of aerating the soil under the turf. Some worm-killers contain salts of lime which frequently produce a per-

manent greasy, moist condition, especially in badly drained turf, and in most cases promote the growth of clovers which should of course be avoided at all costs. Others are acid in character, and if used too freely may reduce the lime content of the surface soil so as to interfere with nitrification.

A solution of corrosive sublimate of 1 in 1,000 has been found effective, but its poisonous properties make it a dangerous substance to place in the hands of the Indian *mali*.

Worm-killers therefore should be employed with great caution, and more especially on turf which has any tendency to become waterlogged, as worm burrows exercise a highly favourable influence upon the surface drainage and aeration of the soil.

It may be pointed out that much harm may be done by rolling in wet worm casts, each of which when flattened out tends to smother the grass under it and produce a bare patch.

Since writing the above it has been found that the selective action of ammonium sulphate upon a mixture of turf grasses, which occurs in the cold weather, and its stimulative effect upon *doob* are very considerably modified during the rains, as soon as the soil becomes sufficiently moist to prevent the necessary concentration of the salt in the top layers, and to produce vigorous growth of the weeds. It is therefore advisable to make use of the method recommended above during the cold weather, although there is no reason why ammonium sulphate and sand, especially the latter, should not be used with advantage to improve the condition of turf during the rains; it is an interesting fact that the obvious improvement in the colour of the grass which follows an application of ammonium sulphate within 48 hours in the dry weather, does not at Pusa make its appearance sometimes for a week or ten days during the rains. This is a question of soil temperature and loss of nitrate by reduction and leaching which is of great scientific interest but will be reserved for publication with a more appropriate context.

In conclusion, it may be said that the study of turf formation under varying conditions of treatment may be made of great interest by any one possessing a few square yards of ground, a fair supply of water, and sufficient interest in the subject.

INVESTIGATIONS ON PAPAYA.

BY

L. B. KULKARNI, L.Ag.,

Bombay Agricultural Department

"*Carica Papaya.* The Papaw.—This well known tree has been subjected to ill-merited abuse, described as ugly and everything that is disagreeable, yet it may be questioned if there is a more handsome or generally useful tree in Indian gardens."—(WOODROW.)

Propagation.

Cuttings.—The only method by which the papaya has so far been propagated is from seeds. Experiments made in the Ganeshkhind Botanical Gardens, Poona, show that vegetative propagation by cuttings and by grafting is possible. The first experiments were made with 5 plants about a foot long which after being transplanted in July, 1913, became rotten below ground level owing to the excessive rains of August. These were uprooted and the rotten portion removed, the upper portions being then planted in a pot and placed in a hot frame. Of these, one struck roots in a month and was transplanted outside, but soon died of exposure. After this about a dozen cuttings from fresh wood were taken and in January, 1914, were planted in the ground, under shade, and treated as usual along with other cuttings. The result was that the cuttings grew pale and rotted below ground. Another attempt was then made in February, 1914, with two dozen cuttings each about one foot long and $\frac{1}{2}$ inch thick, taken from one-year-old wood of a country variety. One dozen cuttings in pots were placed in hot frames

and the other dozen in the ground, under shade. This time the treatment was different. Sand only was used both in pots and outside as a substratum for planting the cuttings. Of those outside, five rotted despite the care taken in watering. Those in the hot frame kept in excellent condition and only one of them died. They produced new leaves in a month while those in the ground were found to be slower in growth.

Grafting.—In January, 1914, 5 male plants just flowering were whip-grafted with scions of the andromonœceous type (plants with male and perfect flowers on same trees). The thickness of the scion was equal to that of the stock, *i.e.*, half an inch. Three of these died and the other two produced new leaves in a month and remained healthy until April, 1914, when one was attacked by insects and the leaves eaten: this graft succumbing in consequence. The second one is now in good condition with new green leaves. The importance of these results lies chiefly in the fact that it may be possible by using these vegetative means of reproduction to settle conclusively some of the questions regarding the inheritance of sex in the papayas. It is doubtful as yet whether they will be of any special value in the practical cultivation of the plant.

Branching of Papaya.

Papaya has a supple, thin, straight trunk branching only when its growth is interfered with. When cultivated it attains the height of from 12 to 20 feet. On account of its considerable height difficulties arise in watching and gathering the fruit. The stems are also easily damaged by wind.

To remove these difficulties, experiments were made in the Ganeshkhind Botanical Gardens, Poona, to encourage branching by the removal of tops of the stems about the time of flowering. Accordingly 10 plants were selected in August, 1910, and the tops of five removed to encourage branching. In a fortnight five to six shoots were produced below the wound, only two being encouraged in each case. Fruits were harvested from December, 1912, to the end of March, 1914. No fruits were obtained from July

to December, 1913. The following table shows the outturn of fruits in branched and unbranched plants :—

Branched.			Unbranched.		
Plant.	No. of fruits.	Average weight in ozs. of each fruit.	Plant.	No. of fruits.	Average weight in ozs. of each fruit.
1	45	56·8	1	19	33·0
2	32	42·0	2	16	28·2
3	30	26·6	3	21	33·7
4	61	45·9	4	31	58·7
5	23	32·0	5	28	66·2
	Total 191	203·3		115	219·8
	Average 38·2	40·65		23·0	43·96

The above table shows that the branched plants gave a greater average number of fruits which were of slightly less average weight. It was observed that the branched plants were less frequently damaged by winds, and the fruit was easy to watch and to harvest. In these circumstances it may be said that the system of branching, if done carefully so as to admit air and light and at the same time to break the force of the wind, will prove most beneficial. In June, 1913, one more plant was operated on with special care. In this case four branches were encouraged, one to each point of the compass. The fruits on each branch were uniform in size and shape and also bigger than the average fruit of other plants. (*See* Fig. 2, Plate XXXIV.)

It may be noted in passing that Mr. F. B. Kilmer in his article on "The Story of Papaya"* states that removing the top of the plant and thereby encouraging more branches and fruit is much more beneficial in cold climates since the plant is protected from frost, and fruit is produced near the ground.

It is also mentioned in *Hawaii Agricultural Experiment Station Report* for 1911, page 30, that to get large sized fruits, it is best to prune off the branches when they first appear.

* *Jamaica Agricultural Department Bulletin*, Vol. 1, Part 8.

PLATE XXXIV.

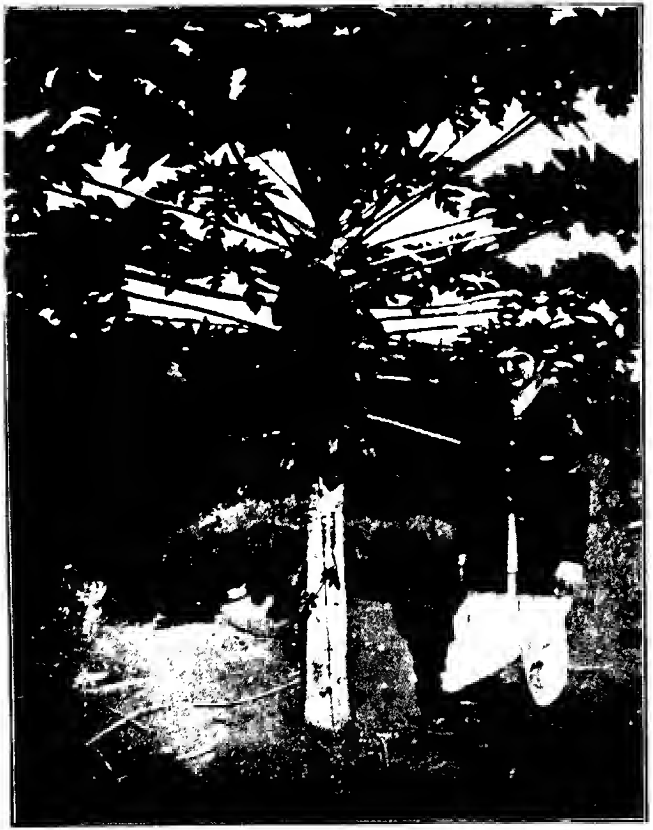


Fig. 1. Large Papayas developed after thinning out the remainder.

Fig. 2. Papaya tree artificially caused to branch

Thinning of Papaya Fruits.

The fruits of the papaya are borne round the stem in such a way that they interfere seriously with each other's growth. It is therefore best to remove a certain number of fruits to allow the rest to develop better.

With this end in view 10 plants in the Ganeshkhind Gardens, Poona, were operated on in September, 1910, one unthinned plant being left for control. The process caused much greater development of the individual fruits (*See* Fig. 1, Plate XXXIV), one being as heavy as 8lbs., and the remainder ranging from 6 to 8lbs. A dealer offered 4 annas each for the thinned fruits. The unthinned tree had many fruits which had crowded and deformed one another. A similar experiment was tried under the writer's advice in a cultivator's field and the results were equally satisfactory.

In 1912 the experiment was again systematically conducted in the Ganeshkhind Gardens, Poona, twenty plants being selected and labelled A and B. The 10 plants labelled 'A' were thinned and the 10 plants labelled 'B' were left unthinned as controls. The variety used was Ceylon. The following table will show that the average number of fruits from the thinned plants is much less than that of the unthinned, but the average weight is correspondingly greater. The estimate of the money value is based on a small number of fruits only which, when sent to the market, brought the following prices:—

THINNED.				UNTHINNED.				REMARKS.
No. of fruits.	Price.			No. of fruits.	Price.			
	Rs.	As.	P.		Rs.	As.	P.	
4	0	[illegible]	0	[illegible]	0	2	9	
6	0	3	6	16	0	13	0	
..	..	..	..	5	0	3	0	
10	0	8	6	24	1	2	9	
The average price per fruit comes to 10·2 pies.				The average price per fruit is 9·3 pies.				

A. THINNED.				B. UNTHINNED.		
Plants.	No. of fruits removed.	Fruits obtained.	Average weight of each fruit in ozs.	Plants.	Fruits obtained.	Average weight in ozs.
1	12	6	39·3	1	20	37·2
2	15	11	34·0	2	23	31·5
3	16	7	48·2	3	11	30·5
4	16	8	51·0	4	15	35·8
5	23	9	47·7	5	14	36·1
6	10	7	44·0	6	11	38·7
7	11	6	36·8	7	15	30·4
8	7	1	27·0	8	28	26·9
9	5	4	42·0	9	11	30·8
10	13	10	37·7	10	11	24·3
Average ...	12·8	6·9	40·0		16·2	32·8

The above results show that the increase of weight is not sufficient to compensate for the loss of fruits in the experiment under consideration. Another experiment gave the following results:—

Plant.	Fruits removed.	Fruits obtained.	Weight.
1	5	9	71·6 ozs.
2	6	7	65·0 ,,
3	7	5	52·3 ,,

Here the weights are greater but the fruits still fewer.

With a small number of, say, six good fruits per plant the experiment may pay ultimately when run on a large scale, *vide* the *Annual Report of the Government Horticultural Gardens, Lucknow* for 1912, where it is stated that an acre of land carrying 1,000 plants, each producing 6 to 10 fruits after thinning may give considerable profit to the grower. The difficulty is to hit on exactly the right amount of thinning to get the greatest weight compatible with the greatest number of fruits. This can only be obtained by practice and in the meantime it is recommended to remove only such fruits as are obviously going to be badly crushed.

NOTES

STIMULATED by the accounts of the successful use made of prickly pear for feeding animals, which appeared in a recent number* of the Journal, the present writer has been making a few desultory trials, following the suggestions therein laid down. He was unable to buy an "Effective" Stove, and had to be content with an ordinary Primus Stove, costing, delivered at Coimbatore, Rs. 9-4-0.

The authors lay great stress on the careful burning of the spines, but do not in the writer's opinion sufficiently emphasize the difficulty of doing this.

It was found on trial that a most prolonged toasting was necessary to get rid of the bunches of "hairs"; it was easy enough to singe the tips, when their unpleasantness was largely alleviated (owing no doubt to the destruction of the 'barbs'), but the 'hairs' themselves persisted in thick tufts and could not be entirely destroyed.

Perhaps some of the readers of this Journal could give the results of their own trials and say with what success they have followed the instructions laid down. The matter is important, because the difficulty of utilising this fodder supply is just what makes it such a valuable reserve in times of scarcity.—(R. CECIL WOOD.)

IN the *Indian Trade Journal* for July 23rd, 1914, there is an interesting note on the efficiency of "the small top milk pail," an American invention of quite recent date, for keeping milk in the pail free from dirt.

The invention consists of an ordinary pail to which is fitted a cover having a small aperture in it on the side furthest from the

* The *Agri. Jour. of India*, Vol. IX, Pt. II, April, 1914.

milker. It has been found that by the use of this simple invention 97 per cent. of the bacteria usually present were kept out, when this pail was used in cowsheds which were not well kept. While under better conditions the milk drawn in the open pail was found to contain $6\frac{1}{2}$ times as many organisms as that collected in the small top pail.

This gives a startling proof of the extraordinary efficiency of this simple appliance—but it is to be strongly urged on all farmers and milkmen that the use of such appliances, effective though they may be, does not render the user free to dispense with the three essential operations to be performed before milking—1 grooming the cow; 2 washing the udder and teats; 3 washing the hands. The small top pail will help those who try to keep their milk clean, but it will not enable the deliberately filthy (the Indian milkman comes under this heading) to continue in his objectionable ways without affecting the milk, and it cannot be too strongly emphasized that none of these inventions will render such operations as milking a cow with a dirty udder into a half-washed pail with a filthy pair of hands, anything but criminal negligence.—(W. SAYER.)

IN the April (1914) number of the *Monthly Bulletin of Agricultural Intelligence and Plant Diseases*, Rome, there is an interesting article by Mr. D. L. Simois (Director of the National School of Agriculture and of Sugar-making at Tucuman, Argentina), on the cultivation of sugar-cane in the Argentine Republic. In it he traces the history of the cultivation of sugar-cane in Argentina from the beginning of the seventeenth century up to 1767 when with the expulsion of the Jesuits the manufacturing of sugar ceased for fifty-four years.

In 1851 the industry was revived by Dr. Colombres, and after several vicissitudes it has reached a stage in 1914, which is best expressed by the simple statement that about 14 millions sterling is now invested in the sugar industry in the Argentine. The area under cane is about 250,770 acres (by Argentine statistics which are not very exact), and of this area the province of Tucuman lays claim to 220,000 acres. It will thus be seen that nearly all the facts

mentioned by the author in his article apply to Tucuman province and not to Argentina as a whole.

The soils on which cane is grown are two in number: (*a*) Loams having up to 90 per cent. of clay most of which is very fine. It is only possible to grow cane on these soils by means of irrigation; (*b*) Humous sands, which have been recently cleared of forests, and still retain much moisture.

Artificials are not generally used, principally for economical reasons. The soils noted above are fertile but deficient in lime, which rarely reaches one per cent. Potash is in excess and Nitrogen and P_2O_5 about normal.

The greater portion of the area is under two varieties of cane: the brown *Morada* (which is in the majority) and the striped *Rayada*—both of which were introduced many years ago. They are, however, considered local varieties as they have developed special characteristics which effectually disguise their origin.

The "Escuela Nacional de Agricultura y Sacarotecnia" of Tucuman is experimenting largely on the cultivation of foreign varieties, and at present has upwards of 250 groups under observation.

Only one system of planting is followed in the Argentine, the cane cuttings, each with three or four eyes, are placed in a continuous series in the bottom of a furrow, which is 8 or 10 inches deep. The rows are from 6 feet to 6 feet 8 inches apart.

The plantation is renewed every 6 or 7 years according to the quality of the soil. Plantations made in September or October are cropped in June or July of the following year, that is at 9 or 10 months old.

Barely a third of the acreage under cane in Tucuman is irrigated, but, even in the localities where irrigation water is available, it is quite exceptional to find estates which irrigate systematically and drain in a suitable manner. Thus it is not rare to find irrigation more injurious than beneficial.

The average yields of cane per acre are as follows:—

Bad years	6½ to 8 tons per acre.
Normal ,,	9 to 10½ ,,
Good ,,	11 to 14 ,,
Very good years	16 to 20 ,,

This gives a range of from 6½ tons to 20 tons per acre. The cost of production is from 8s. 6d. to 12s. 6d. per ton of cane, and the sale price varies from 19s. 6d. to 25s. There are at present 38 sugar factories in Argentina of which 28 are in Tucuman.

Owing to the improvement of the machinery the amount of sugar extracted from the cane as delivered at the factory has risen from 3lbs. sugar per 100lbs. cane in 1870 up to an average yield of above 9·5 lbs. sugar per 100lbs. cane, which was obtained by the most modern mills in 1913.

It is noteworthy that the experimental station referred to above has opened a small sugar factory of its own, capable of crushing 30 tons of cane per day, and this should, by its practical demonstration in the hands of experts, assist greatly in the further improvement of the methods of sugar-making.

Foreign refined sugar pays 1¾d. per lb. duty, which will be lowered to 1½d. per lb. in 1921, by which time the local industry should be able to fend for itself.

There are at present only four sugar refineries in the country, but others are being built, and everything seems to point to a thriving and profitable industry on a large scale in the near future.—(W. SAYER.)

* * *

The Agricultural News of the West Indies, reports the successful experiment, by the Agricultural Department, of sending cane cuttings in damp charcoal (1lb. charcoal, 4oz. of water) to India by parcel post, thereby lessening the time and the consequent risk in the usual method of transportation by ship. As the maximum weight allowed for sending by parcel post is 11lbs. special tins were constructed, and the size of the cane cuttings was reduced to a minimum. The light tins employed measured 18 inches × 4 inches × 4 inches, and cuttings were selected, having the nodes moderately close together, thereby getting a good number of buds per cutting with a minimum bulk of cane.

The time taken during the transportation was only six weeks. On its arrival in India, the case of cuttings was opened immediately. Many of the buds were found to have already sprouted, the sprouts

varying from ½ inch to 2 or 3 inches in length. In a few cases rootlets had developed 1 to 2 inches long. These looked in perfect condition and were unbroken and undamaged. The canes themselves were perfectly healthy in appearance, not in the least dried or shrivelled up, quite hard, and bright in colour.

The cuttings were planted out at once, and it is reported by the Agricultural Chemist, Assam, that they had all germinated and were doing well.

The trial was reciprocated in India by forwarding cuttings of Dacca *ganderi* by the same method to the West Indies where the parcel is reported to have been received in good condition.—(EDITOR.)

* * *

THE steadily rising prices of bullocks and of agricultural produce enhance the interest of an article on Power Pumping in the May (1914) number of *The Indian Agricultural World*, by Mr. W. M. Schutte, Engineer of the Bombay Agricultural Department.

Mr. Schutte, who has had 15 years' experience of pumping work, compares the annual expenses of lifting water for the irrigation of from 15 to 20 acres, from heights of from 30 to 45 feet, in various districts in Bombay, by mhotes and by centrifugal pumps respectively the figures being taken from plants actually at work on cultivators' lands. The average cost works out at something less than half in the case of the centrifugal pump, being very much less in every instance.

The remainder of the article is devoted to a short but useful discussion of some of the advantages and disadvantages of various types of prime mover including engines driven by steam, crude oil, paraffin, petrol, gas, and suction gas. The cultivators of the Bombay Presidency are lucky in being able to avail themselves of the services of a consulting engineer for this class of work.

OF recent years there has been a steady increase in the export to foreign countries of some of the important manures produced in India, such as bones, oil cakes, fish guano, etc., which indicates

that Indian cultivators have not yet fully realised the value of the application of such manures to their land. Owing to religious scruples bones are not used to any large extent but in some places their application has resulted in increased outturn, especially for the paddy crop in parts of Bengal and Assam, and there seems to be every probability of their use being extended in these parts.

Oil cake constitutes one of the most important organic nitrogenous manures available in India, but its use is confined to a limited extent, its value is however fully appreciated in certain Districts such as Poona and Assam, and the experience of such places should be useful in introducing its use into similar localities.

The following figures of export are for the last three years and have been taken from Part II (1914) of the *Quarterly Journal of the Indian Tea Association* :—

Statement showing the quantity and value of different kinds of manures exported from India to different countries during 1910-11, 1911-12, *and* 1912-13.

BONES.

Exported to	Quantity—Tons. 1910-11.	Quantity—Tons. 1911-12.	Quantity—Tons. 1912-13.	Value—in Sterling. 1910-11.	Value—in Sterling. 1911-12.	Value—in Sterling. 1912-13.
	Tons.	Tons.	Tons.	£	£	£
United Kingdom ..	14,056	13,269	15,454	59,958	62,085	74,843
Ceylon	6,482	8,648	8,781	21,676	32,061	32,739
Straits Settlements (including Labuan) ..	45	5	81	119	22	123
Hongkong ..	2,661	758	15	12,312	3,531	85
Natal	825	750	300	3,467	3,750	1,436
Western Australia ..	30	..	..	..	..	..
New Zealand ..	7,310	4,002	3,739	34,127	20,201	19,602
Other British Possessions	..	7	..	..	30	..
Germany ..	9,952	9,553	13,006	44,526	47,604	65,627
Holland	400	..	..	1,785	..	..
Belgium	23,262	29,894	33,822	191,940	137,803	159,332
France	13,249	13,419	17,089	57,833	62,289	81,788
Austria-Hungary ..	..	10	441	..	33	2,297
Japan	4,659	6,247	9,170	20,533	29,431	46,609
U.S.A. Atlantic Coast	750	400	2,927	3,299	2,000	14,171
U.S.A. Pacific Coast		1,400	4,834		6,860	24,031
Sandwich Islands ..	..	600	550	..	2,920	2,693
Other Foreign Countries	1	1	12	5	3	63
Total ..	Tons 83,682	88,963	110,221	£361,694	410,623	525,739

FISH MANURES AND GUANO.

Exported to	Quantity—Tons. 1910-11.	Quantity—Tons. 1911-12.	Quantity—Tons. 1912-13.	Value—in Sterling. 1910-11.	Value—in Sterling. 1911-12.	Value—in Sterling. 1912-13.
	Tons.	Tons.	Tons.	£	£	£
Ceylon	11,161	14,629	17,885	42,652	45,290	53,429
Straits Settlements (including Labuan) ..	2,192	3,157	3,242	8,967	12,780	14,464
Hongkong ..	92	176	31	434	1,272	187
Zanzibar and Pemba ..	105	..	2	700	..	5
Germany	..	555	112	..	2,417	667
Japan	22	106	136	115	391	662
German East Africa ..	37	..	..	250	..	..
Total ..	Tons 16,609	18,623	21,408	£53,118	62,150	69,414

OTHER KINDS.

Exported to	Quantity—Tons. 1910-11.	Quantity—Tons. 1911-12.	Quantity—Tons. 1912-13.	Value—in Sterling. 1910-11.	Value—in Sterling. 1911-12.	Value—in Sterling. 1912-13.
	Tons.	Tons.	Tons.	£	£	£
United Kingdom ..	369	404	1,379	2,500	2,810	6,922
Aden and Dependencies	5	49	26	35	420	208
Ceylon	902	682	2,543	5,352	5,241	11,994
Straits Settlements (including Labuan) ..	419	344	17	3,590	2,388	172
Other British Possessions	..	..	27	..	..	52
Germany	950	895	916	5,384	4,996	4,439
France	..	18	110	..	99	887
Austria-Hungary ..	..	26	188	..	170	756
Native States in Arabia other than Maskat-Territory and Trucial Oman	1	13	11	4	115	94
Japan	224	305	586	1,956	1,204	2,972
U.S.A. Atlantic Coast	967	1,373	2,500	8,106	11,353	22,303
U.S.A. Pacific Coast		191			1,780	
Other Foreign Countries	15	6	14	73	53	91
Total ..	Tons 3,852	4,306	8,338	£27,000	30,629	50,890

OIL CAKES (ALL KINDS).

Exported to	QUANTITY—TONS. 1910-11.	1911-12.	1912-13.	VALUE—IN STERLING. 1910-11.	1911-12.	1912-13.
	Tons.	Tons.	Tons.	£	£	£
United Kingdom	627,585	740,187	933,805	119,650	177,957	226,898
Ceylon	944,688	856,685	964,723	243,157	250,285	292,826
Straits Settlements (including Labuan) ..	64,670	35,955	16,241	15,021	8,138	11,648
Hongkong	20,602	13,336	41	3,916	2,243	8
Mauritius and Dependencies	100	..	..	29	..	
Other British Possessions	100	371	258	33	73	53
Germany	293,420	548,914	501,563	77,539	140,381	130,381
Holland	..	2,001	9,823	..	642	3,512
Belgium	2,000	5,008	..	400	1,058	..
France	2,380	2,995	..	678	840	..
Java	25,800	8,820	20,692	6,820	1,984	5,157
Indo-China (including Cochin China, Cambodia, Annam and Tonkin) ..	15,900	23,440	12,603	3,737	4,918	2,533
China (exclusive of Hongkong and Macao)	..	24,258	9,155	..	3,842	1,583
Japan	297,576	502,468	736,786	58,606	98,559	146,153
Other Foreign Countries	35	..	13	8	..	5
TOTAL ..	TONS 2,294,856	2,761,438	3,235,703	£559,704	690,920	821,387

TOTAL (ALL MANURES).

Kind.	QUANTITY—TONS. 1910-11.	1911-12.	1912-13.	VALUE—IN STERLING. 1910-11.	1911-12.	1912-13.
	Tons.	Tons.	Tons.	£	£	£
Animal Bones ..	83,682	88,963	110,221	361,694	410,623	525,739
Fish Manure ..	16,421	18,356	21,408	52,208	60,959	69,411
Guano	188	267		910	1,191	
* Oil cake (all kinds including manures) ..	55,516	59,799	3,235,703	244,319	270,989	821,387
Other kinds ..	3,852	4,306	8,338	27,000	30,629	50,890
TOTAL ..	TONS 159,659	171,691	3,375,670	£686,331	774,391	1,467,430

* The figures for 1910-11 and 1911-12 represent exports of "Oil cake (manure)," while those for 1912-13 represent "Oil cake (all kinds including manures).—(EDITOR.)

REVIEWS

TUBE WELLS—BORING, SINKING, AND WORKING.—By T. A. MILLER BROWNLIE, C.E. Second Edition (obtainable from Messrs. Thacker, Spink & Co., Calcutta). Price, Rs. 5.

THE chief aim of this little book is to describe various methods of boring and pumping systems, which may be adopted to suit the convoluted Tube Well.

The well of this type designed by the author was described in Vol. VIII, Part II, of this Journal. Should the type prove with continuous working to yield the results claimed by the author, there is no doubt that there is an important future before it for irrigation purposes—perhaps more particularly in the more recent alluvial soils where the open tube type of well is rarely a success owing to the difficulty of finding a '*mota*' or clay bed sufficiently strong to support the overlying strata over an actual cavity in the water-bearing stratum.

While there are other types of tube well in the market, and only time can show which is the best for any given set of local conditions, none of the older types have yet proved in the long run entirely satisfactory and this book should be a useful incentive to the more general trial of the type invented by the author.

We would, however, add a word of caution. The book is written by an Engineer for Engineers, and those who are not Engineers by profession should not be misled, by the apparent ease of manipulation of the various plants described, into undertaking boring or pumping operations without professional assistance.—(A. C. D.)

THE ANNALS OF APPLIED BIOLOGY, Vol. I, No. 1; pages 1—106, 8 plates and 14 text figures; Cambridge University Press. Price, 7/6 nett.

THIS new magazine, to adopt the words of the editorial preface, "is intended to cover the ground in applied biology which is not now covered by special journals." It seems difficult to imagine any branch of biology, applied or not, which is not already provided with literary channels—there are, for instance, upwards of two thousand periodicals which may contain articles dealing with entomology—and fresh additions to the lengthy list can hardly be hailed with joy by the ordinary worker who has to extract and record the various papers contained in them. However, each new venture must be taken on its merits and these will doubtless determine its success or failure.

The "Annals" open with an article by Professor F. W. Gamble on "Impending Developments in Agricultural Zoology," which notes briefly recent progress in the Fauna of the soil as regards Protozoa, Nematodes, Earthworms, and the Parasitic Helminths. The following sentences are extracted from the concluding paragraph:—"We need a careful census of the country, a census that is of the animals and the animal-borne diseases affecting agriculture. We need more work, far more work, on the life-histories of the groups in question, whether indifferent, noxious, or beneficial." These words are apparently intended to apply especially to conditions in England but might well be used, still more forcibly, of India.

It is impossible to notice all of the nine papers contained in this number. An article by R. H. Deakin on Power-Spraying of Oak-trees in Richmond Park contains five plates which show the apparatus employed. On page 79 occurs a statement that "*Gypnosoma dealbana* Frol., I am told, has not previously been recorded from the oak;" a reference to Meyrick's excellent Handbook, or even to Stainton's obsolete manual, would have rectified this impression, whilst Frolich's original description of the species records it as "in quercu."

An excellent and clearly-written article by E. E. Green on the preparation of scale-insects for microscopical study concludes the first number of the Annals, to which we wish every success.—(T. B. F.)

CROP-PEST HANDBOOK FOR BIHAR AND ORISSA (INCLUDING ALSO WESTERN BENGAL). (Pages 1-xxiii + 1-141 and 55 Plates.) (Messrs. Thacker, Spink & Co.) Price, Rs. 4.

THIS Handbook has been compiled by Messrs. S. K. Basu and H. L. Dutt, Assistant Professors of Mycology and Entomology at the Agricultural College at Sabour, under the direction and supervision of Mr. E. J. Woodhouse, Economic Botanist to the Government of Bihar and Orissa. It was fully completed and should have been issued two years ago—it may be noted, by the way, that the date of publication as given on the title-page is incorrect, the book not having been issued until June 1914—but publication was delayed owing, we are told, to "difficulties in obtaining funds due to the re-partition of Bengal."

The book is a collection of eighty-four leaflets on the more commonly occurring pests and diseases of crop-plants: only the former are dealt with in this review. These are noticed under the headings of Names, Nature of Damage, Locality and Time of Appearance, Foodplants, Description and Life-history, Enemies, Remedies, and References to previously published literature of the Agricultural Department. The illustrations comprise fifty-five Plates of which forty-five are coloured and nearly all of these represent insects, but most of the uncoloured Plates would better have been described as text-figures (*e.g.*, "Plates" XIX and XX). Each of the leaflets which compose the book is paged separately: so far as the bound volume is concerned it would have made for convenience if the pages had also been numbered consecutively; this procedure would have allowed more ready reference by means of the Index of Plants and that of Pests, both of which might have been made rather more complete.

As regards the plan of the work, this is based on a classification of crops, which are considered in further detail under the heads of Cereals, Pulses, Oilseeds, Fibres, Spices, Drugs and Narcotics, Sugar, Dyes, Vegetables, Fruits, Palms, and Pests of Stored Grain. As it is obvious that such a classification has this disadvantage, that a common polyphagous pest may be placed under more than one of

these headings, a list of crop-pests is provided (Preface, pages x-xxiii), *giving a list of crops with the chief pests of each* and a reference as to where the description of each pest will be found in the book. Many insects, which are noted as Minor Pests, only appear in this list, not being referred to further.

This book is noteworthy as being the first attempt by a Provincial Department of Agriculture to issue any general and connected account of the numerous pests which take so large a toll of the farmer's produce. It is to be hoped, therefore, that it will be accorded a hearty welcome by, and prove of real use to, those educated members of the cultivating class for whom it has been written. If the price could have been reduced, it would doubtless have been appreciated still more, but we understand that the various leaflets composing the book are available separately to *bonâ fide* cultivators.—(T. B. F.)

*
* *

PLANTATION WHITE SUGAR MANUFACTURE.—By W. H. Th. HARLOFF and H. SCHMIDT. Translated by J. P. OGILVIE, F.C.S., and published by Norman Rodger, 2, St. Dunstan's Hill, London, E.C. 1913. Price, *7s. 6d.* net.

THE main object of this little manual of 135 pages is, as the authors say, a discussion of the two methods of clarification of the raw juice, *viz.*, Carbonatation and Sulphitation.

As the success of the manufacture of the white sugar chiefly depends on a true and clear conception of the chemistry of these two methods, no pains have been spared to give a thorough description of the various stages, together with comparative statements of the merits of each of the processes, and a full discussion as to why such and such course is recommended in preference to others. Many of the everyday difficulties have been fully examined and means suggested for preventing or overcoming them.

Great stress has very rightly been laid throughout on the importance of correct liming.

The five introductory chapters on the influence of acids and alkalies, and of the heat, on the constituents of cane juice, on the

colouring substances of the cane; and on the different fermentations, which may occur in the Sugar Factory, should be studied by every one interested in the manufacture of Sugar.

The chapters on the treatment of the muddy juice and the curing of the sugar are all well written, and give much practical information.

Those interested in Indian Factories would do well to take particular note of the effects of indifferent liming, and of the corrosion caused by Sulphurous acid vapours.—(M. N. C.)

LIST OF AGRICULTURAL PUBLICATIONS IN INDIA FROM 1st FEBRUARY TO 31st JULY, 1914.

No.	Title.	Author.	Where published.
	GENERAL AGRICULTURE		
1	The *Agricultural Journal of India*, Vol. IX, Parts II and III Price per Part, Rs. 2; annual subscription, Rs. 6.	Issued from the Agricultural Research Institute and College, Pusa, Bihar	Messrs. Thacker, Spink & Co., Calcutta.
2	Report on the Progress of Agriculture in India for 1912-13. Price As. 8 or 9*d*.	Agricultural Adviser to the Government of India, Pusa.	Government Printing, India, Calcutta.
3	Report of the Agricultural Research Institute and College, Pusa (including the Report of the Imperial Cotton Specialist) for 1912-13. Price As. 7 or 8*d*.	Ditto.	Ditto.
4	Agricultural Sayings of Bengal with Analogous Sayings in Bihar and Orissa Bulletin No 1 of 1913 Price As. 6.	P L Banerjee ...	Bengal Secretariat Book Depôt, Calcutta.
5	Season and Crop Report of Bengal for 1913-14. Price As. 15.	Issued by the Department of Agriculture, Bengal.	Ditto.
	Season and Crop Report of Bihar and Orissa for 1913-14.	Issued by the Department of Agriculture, Bihar and Orissa.	Government Press, Gulzarbagh.
7	The Agricultural Journal, April, 1914 (issued half-yearly), subscription Re. 1.	Ditto.	Ditto
8	Names of the field and market garden crops and of the principal fruit and timber trees of the United Provinces Bulletin No. 30 (revised edition of Bull. No. 4 of the Department of Agriculture, United Provinces) Price As. 7.	Issued by the Department of Agriculture, United Provinces	Government Press, United Provinces, Allahabad.
9	Annual Report of the Agri-horticultural Gardens, Lahore, for 1912-13.	Issued by the Department of Agriculture, Punjab.	Government Printing, Punjab, Lahore.
10	List of ploughs and other Agricultural Implements recommended by the Punjab Agricultural Department. (Illustrated.) 1914.	Ditto.	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title.	Author.	Where published.
	General Agriculture—contd.		
11	Annual Report of the Surat Agricultural Station for 1912-13. Price Re. 1 or 1*s.* 6*d.*	Issued by the Department of Agriculture, Bombay.	Government Central Press, Bombay.
12	Annual Report of the Dhulia Agricultural Station for 1912-13 Price Re. 1 or 1*s.* 6*d.*	Ditto.	Ditto
13	Annual Report of the Nadiad Agricultural Station for 1912-13. Price As. 14 or 1*s.* 4*d.*	Ditto.	Ditto.
14	Annual Report of the Dohad Agricultural Station for 1912-13. Price As. 12 or 1*s.* 2*d.*	Ditto.	Ditto.
15	Annual Report of the Dharwar Agricultural Station for 1912-13. Price Re. 1 or 1*s.* 6*d.*	Ditto.	Ditto.
16	Annual Report of the Gokak Agricultural Station for 1912-13. Price As. 14 or 1*s.* 4*d.*	Ditto.	Ditto
17	Annual Report of the Gadag Agricultural Station for 1912-13. Price As. 14 or 1*s.* 4*d.*	Ditto.	Ditto.
18	Annual Report of the Mirpurkhas Agricultural Station for 1912-13. Price As. 7 or 8*d.*	Ditto.	Ditto.
19	Annual Report of the Sukkur Agricultural Station for 1912-13. Price As. 6 or 7*d.*	Ditto.	Ditto.
20	Annual Report of the Alibag Agricultural Station for 1912-13. Price As. 10 or 11*d.*	Ditto.	Ditto.
21	Annual Report of the Poona Agricultural College Station. Price As. 8 or 9*d.*	Ditto.	Ditto.
22	Proceedings of the Agricultural Conference held at Poona in September, 1913. Price Re. 1-4 or 1*s.* 10*d.*	W. W. Smart, I.C.S., Offg. Director of Agriculture, Bombay.	Ditto.
23	The advantages of co-operative sale of cotton.	H. C. Sampson, B.Sc., F.H.A.S., F.B.S.E., Deputy Director of Agriculture Southern Division, Madras.	Government Press, Madras.
24	The Fodder Question in Coimbatore.	R. Cecil Wood, M.A., Principal, Agricultural College, Coimbatore.	Ditto.
25	The *Monthly Agricultural and Co-operative Gazette*, February to July, 1914. Price per copy As. 2.	Issued by the Department of Agriculture, Central Provinces & Berar.	Deshsevak Press, Nagpur.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title.	Author.	Where published.
	General Agriculture—concld.		
26	Report on the Season and Crops of Assam for 1913-14. Price As. 8 or 9*d*.	Issued by the Department of Agriculture, Assam	Assam Secretariat Printing Office, Shillong.
27	Season and Crop Report of Burma for 1913-14. Price As. 8 or 9*d*	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
28	Report of the Mandalay Agricultural Station for the year 1912-13.	Ditto.	Ditto.
29	Report of the Hmawbi Agricultural Station for the year 1912-13.	Ditto.	Ditto.
30	A trial of orange stocks at Peshawar (reprinted from the *Agricultural Journal of India* for January 1914).	W. Robertson Brown, Agricultural Officer, North West Frontier Province.	Messrs Thacker, Spink & Co., Calcutta.
31	*Quarterly Journal of the Indian Tea Association*. Parts I and II of 1914.	Scientific Department of the Indian Tea Association, Calcutta.	The Catholic Orphan Press, Calcutta.
32	The *Poona Agricultural College Magazine*, Vol. V, No. 4, and Vol. VI, No. 1. Annual subscription Rs. 2, single copy As 9.	College Magazine Committee, Poona	Arya Bhushan Press, Poona.
33	Tube Wells—Boring, Sinking, and Working (Second Edition). Price Rs. 5.	C. A. Miller Brownlie, C.E.	Messrs. Thacker, Spink & Co., Calcutta.
34	Rye grass and clover in India (reprinted from the *Agricultural Journal of India* for January 1914).	W. Robertson Brown, Agricultural Officer, N.-W. F. Province.	Ditto.
35	The *Indian Agricultural World* (monthly). Subscription Rs. 10.	Messrs. P. A. V. Iyer & Co., Triplicane, Madras, S.E.	Commercial Press, Madras.
36	*Indian Poultry Gazette* (monthly). Subscription Rs. 3 per annum.	Issued by the Indian Poultry Club, Lucknow.	Mafusilite Electrical Printing Works, Mussoorie.
	AGRICULTURAL CHEMISTRY.		
37	The Fractional Liquefaction of Rice Starch. Memoirs of the Department of Agriculture in India, Chemical Series, Vol III, No. 5. Price Re. 1 or 1*s*. 6*d*.	F. J. Warth, M.SC., Agricultural Chemist, Burma; and D. B. Darabsett, B.SC., Senior Assistant to the Agricultural Chemist, Burma.	Messrs. Thacker, Spink & Co., Calcutta.
38	The Yield and Composition of the Milk of the Montgomery Herd at Pusa and Errors in Milk Tests. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. III, No. 6. Price Re. 1 or 1s. 6d.	J. W. Leather, PH.D., F.I.C., Imperial Agricultural Chemist; and A. C. Dobbs	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title.	Author.	Where published.
	Agricultural Chemistry—concld.		
39	Disintegration of Rice Grains by means of Alkali. Bulletin No 38 of the Agricultural Research Institute, Pusa Price 6 annas or 7*d*.	F. J. Warth, M.Sc., Agricultural Chemist, Burma; and D. B. Darabsett, B.Sc., Senior Assistant to the Agricultural Chemist, Burma.	Government Printing India, Calcutta.
	BOTANY		
40	The Seed Supply of the New Pusa Wheats (English, Hindi, and Urdu).	A. Howard, C.I.E., M.A., A.R.C.S., F.L.S., Imperial Economic Botanist; and Gabrielle L. C. Howard, M.A., Personal Assistant to the Imperial Economic Botanist.	The Baptist Mission Press, Calcutta.
41	Bengali translation of Mr. Howard's paper on the Yield and Quality of Wheat in India	Issued by the Department of Agriculture, Bengal.	Bengal Secretariat Book Depôt, Calcutta
	MYCOLOGY		
42	Bengali translation of Dr. E. J. Butler's paper on the Ufra Disease of Rice.	Issued by the Department of Agriculture, Bengal.	Ditto.
43	Cultivators' Leaflet No. 44. The Sypmtoms of "Ufra" Disease of Rice.	A. McKerral, M.A., B.Sc., Deputy Director of Agriculture, Southern Circle, Burma.	Government Printing, Burma, Rangoon.
	ENTOMOLOGY		
44	The Psylla Disease of Indigo. Memoirs of the Department of Agriculture in India, Entomological Series, Vol. IV, No. 6. Price Re. 1-8-0.	A. J. Grove, M.Sc., offg. Imperial Entomologist; and C. C. Ghosh, B.A., Assistant to the Imperial Entomologist.	Messrs. Thacker, Spink & Co., Calcutta.
45	Life Histories of Indian Insects—V (*Lepidoptera*). Memoirs of the Department of Agriculture in India Entomological Series, Vol. V, No. 1. Price Rs. 2-8-0.	C. C. Ghosh, B.A., Assistant to the Imperial Entomologist.	Ditto
46	Instructions for rearing Mulbery Silk worms. Bulletin No. 39 of the Agricultural Research Institute, Pusa. Price As. 4 or 5*d*.	M. N. De, M.S.A., Sericultural Assistant to the Imperial Entomologist.	Government Printing, India, Calcutta.
47	Note on the Green Scale of Coffee (*Lecanium virіde*).	T. Bainbrigge Fletcher, R.N., F.E.S., F.Z.S., Imperial Entomologist.	Government Press, Mercara, Coorg.
48	Large Brown Cockroach. Leaflet No. 1 of 1914 (in English and Bengali)	P. C. Sen, Entomological Collector, Bengal.	Obtainable from the Department of Agriculture, Bengal.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title.	Author.	Where published.
		Entomology—contd.	
49	*Dhanerpoka* or Insect Enemies of Rice (in Bengali). Price As. 8.	P. C. Sen, Entomological Collector, Bengal.	Obtainable from the Department of Agriculture, Bengal.
50	Crop Post Handbook for Bihar and Orissa (including Western Bengal). Price Rs. 1.	Issued by the Department of Agriculture, Bihar and Orissa.	Messrs. Thacker, Spink & Co., Calcutta.
51	Some Remarks on Fishery Questions in Bengal. Fishery Bulletin No. 4 of 1914. Price As. 5.	T. Southwell, Deputy Director of Fisheries.	Bengal Secretariat Book Depôt, Calcutta.
52	Practical Instructions for the Kollegal Mulberry Silkworm rearers.	T. Bainbrigge Fletcher, R.N., F.E.S., F.Z.S., Government Entomologist, Madras.	Government Press, Madras
53	Some General Methods of Controlling attacks by Insect Pests—Agricultural Methods.	Ditto.	Ditto.
54	Some General Methods of Controlling attacks by Insect Pests—Mechanical Methods.	Ditto.	Ditto.
		AGRICULTURAL BACTERIOLOGY.	
55	Green Manuring Experiment, 1912-13. Bulletin No 40, of the Agricultural Research Institute, Pusa. Price As. 4 or 5*d*	C. M. Hutchinson, M.A., F.E.S., Imperial Agricultural Bacteriologist.	Government Printing, India, Calcutta.
		VETERINARY.	
56	The Curative Treatment of Hæmorrhagic Septicæmia in Cattle by the administration of Iodine and other Notes on Chemiotherapy in Rinderpest and Hæmorrhagic Septicæmia. Memoirs of the Department of Agriculture in India, Veterinary Series, Vol. II, No. 3. Price Re. 1 or 1*s*. 6*d*.	Major J. D. E. Holmes, C.I.E., M.A., D.Sc., I.C.V.D., Imperial Bacteriologist, Muktesar	Messrs. Thacker, Spink & Co., Calcutta.
57	The Vitality of the Hæmorrhagic Septicæmia Organism outside the Body. Memoirs of the Department of Agriculture in India, Veterinary Series, Vol. II, No. 4. Price Re. 1 or 1*s* 6*d*.	Ditto.	Ditto.
58	Annual Report of the Imperial Bacteriologist for 1912-13. Price As. 3 or 4*d*.	Issued by the Agricultural Adviser to the Government of India.	Government Printing India, Calcutta.
59	Annual Report of the Civil Veterinary Department, Bihar and Orissa, for 1913-14.	Issued by the Veterinary Department, Bihar and Orissa.	Government Press, Gulzarbagh.

LIST OF AGRICULTURAL PUBLICATIONS—*concld.*

No.	Title.	Author.	Where published.
		Veterinary—contd.	
60	Annual Report on the Civil Veterinary Department, United Provinces, for the year ending 30th March, 1914. Price As. 8 or 9*d*.	Issued by the Department of Agriculture, United Provinces.	Government Press, United Provinces, Allahabad.
61	Notes on Glanders. Bulletin No. 31, of the Department of Land Records and Agriculture, United Provinces. Price As. 2.	E. W. Oliver, M.R.C.V.S., F.Z.S., Superintendent, Civil Veterinary Department.	Ditto.
62	Annual Report of the Camel Specialist for 1912-13.	Issued by the Department of Agriculture, Punjab.	Government Printing, Punjab, Lahore.
63	Equine Biliary Fever ...	J. F. Valladares, Deputy Superintendent, Civil Veterinary Department, Central Provinces.	Printed in *Parasitology*, May 1914, published by Messrs. Macmillan & Co., Ltd., Bombay and Calcutta.
64	Report of the Civil Veterinary Department, Assam, for 1913-14. Price As. 8 or 9*d*.	Issued by the Civil Veterinary Department, Assam.	Assam Secretariat Printing Office, Shillong.

PUBLICATIONS OF THE IMPERIAL DEPARTMENT OF AGRICULTURE IN INDIA

To be had from

The Office of the Agricultural Adviser to the Government of India, Pusa, Bihar,

and from the following Agents:—

(1) THACKER, SPINK & CO., Calcutta.
(2) W. NEWMAN & CO., ,,
(3) Rai M. C. SARKAR Bahadur & SONS, Calcutta.
(4) HIGGINBOTHAMS Ltd., Madras.
(5) THOMPSON & CO., ,,
(6) D. B. TARAPOREVALA SONS & CO., Bombay.
(7) THACKER & CO., Bombay.
(8) SUNDER PANDURUNG, Bombay.
(9) Rai Sahib M. GULAB SINGH & SONS, Lahore.
(10) MANAGER, Educational Book Depôt, Nagpur.

Annual Report of the Imperial Department of Agriculture in India for the year 1904-05. Price, As. 12 or 1*s.* 2*d.* (*Out of print.*)

Report of the Imperial Department of Agriculture in India for the years 1905-06 and 1906-07. Price, As. 6 or 7*d.*

Report of the Agricultural Research Institute and College, Púsa (including the Report of the Imperial Cotton Specialist) for the years 1907-09. Price, As. 4 or 5*d.*

Report of the Agricultural Research Institute and College, Púsa (including the Report of the Imperial Cotton Specialist) for the year 1909-10. Price, As. 4 or 5*d.*

Report of the Agricultural Research Institute and College, Púsa (including the Report of the Imperial Cotton Specialist) for 1910-11. Price, As. 6 or 7*d.*

Report of the Agricultural Research Institute and College, Púsa (including the Report of the Imperial Cotton Specialist) for 1911-12. Price, As. 6 or 7*d.*

Report of the Agricultural Research Institute and College, Púsa (including the Report of the Imperial Cotton Specialist) for 1912-13. Price, As. 7 or 8*d.*

Report on the Progress of Agriculture in India for the years 1907-09. Price, As. 6 or 7*d.*

Report on the Progress of Agriculture in India for the year 1909-10. Price, As. 6 or 7*d.*

Report on the Progress of Agriculture in India for the year 1910-11. Price, As. 12 or 1*s.* 3*d.* (*Out of print.*)

Report on the Progress of Agriculture in India for the year 1911-12. Price, As. 6 or 7*d.*

Report on the Progress of Agriculture in India for the year 1912-13. Price, As. 8 or 9*d.*

Proceedings of the Board of Agriculture in India, held at Púsa on the 6th January 1905 and following days (with Appendices). Price, As. 8 or 9*d.*

Proceedings of the Board of Agriculture in India, held at Púsa on the 15th January 1906 and following days (with Appendices). Price, As. 12 or 1*s.* 2*d.*

Proceedings of the Board of Agriculture in India, held at Cawnpur on the 18th February 1907 and following days (with Appendices). Price, Re. 1-2 or 1*s.* 6*d.*

Proceedings of the Board of Agriculture in India, held at Púsa on the 17th February 1908 and following days (with Appendices). Price, As. 8 or 9*d.*

Proceedings of the Board of Agriculture in India, held at Nagpur on the 15th February 1909 and following days (with Appendices). Price, As. 8 or 9*d.*

Proceedings of the Board of Agriculture in India, held at Púsa on the 21st February 1910 and following days (with Appendices). Price, As. 8 or 9*d.*

Proceedings of the Board of Agriculture in India, held at Púsa on the 20th November 1911 and following days (with Appendices). Price, As. 10 or 1*s.* (*Out of print.*)

Proceedings of the Board of Agriculture in India, held at Coimbatore on the 8th December 1913 and following days (with Appendices). Price, Re. 1-2 or 1*s.* 9*d.*

Standard Curriculum for Provincial Agricultural Colleges as recommended by the Board of Agriculture, 1908. Price, As. 4 or 5*d.*

The *Agricultural Journal of India.*—A Quarterly Journal dealing with subjects connected with agricultural economics, field and garden crops, economic plants and fruits, soils, manures, methods of cultivation, irrigation, climatic conditions, insect pests, fungus diseases, co-operative credit, agricultural cattle, farm implements and other agricultural matters in India. Illustrations, including coloured plates, form a prominent feature of the Journal. It is edited by the Agricultural Adviser to the Government of India, assisted by an Advisory Committee of the Staff of the Agricultural Research Institute, Púsa. *Annual Subscription*, Rs. 6 or 8*s.* 6*d.* including postage. Single copy, Rs. 2 or 3*s.*

MEMOIRS OF THE DEPARTMENT OF AGRICULTURE IN INDIA are issued from time to time as matter is available, in separate series, such as Chemistry, Botany, Entomology, and the like.

BOTANICAL SERIES.

Vol. I, No. I. Studies in Root-Parasitism. The Haustorium of *Santalum album*.—Part I.—Early Stages up to Penetration, by C. A. BARBER, M.A., F.L.S. Price, Re. 1. (*Out of print.*)
Part II.—The Structure of the Mature Haustorium and the Inter-relations between Host and Parasite, by C. A. BARBER, M.A., F.L.S. Price, Rs. 3. (*Out of print.*)

Vol. I, No. II. Indian Wheat Rusts, by E. J. BUTLER, M.B., F.L.S., and J. M. HAYMAN, D.V.S. Price, Rs. 3. (*Out of print.*)

Vol. I, No. III. Fungus Diseases of Sugarcane in Bengal, by E. J. BUTLER, M.B., F.L.S. Price, Rs. 3.

Vol. I, No. IV. *Gossypium obtusifolium*, Roxburgh, by I. H. BURKILL, M.A. Price, Re. 1.

Vol. I, No. V. An Account of the Genus *Pythium* and some *Chytridiaceæ*, by E. J. BUTLER, M.B., F.L.S. Price, Rs. 4-8.

Vol. I, No. VI. *Cephaleuros virescens*, Kunze; The 'Red Rust' of Tea, by HAROLD H. MANN, D.Sc., F.L.S.; and C. M. HUTCHINSON, B.A. Price, Rs. 4. (*Out of print.*)

Vol. II, No. I. Some Diseases of Cereals caused by *Sclerospora graminicola*, by E. J. BUTLER, M.B., F.L.S. Price, Re. 1-8.

Vol. II, No. II. The Indian Cottons, by G. A. GAMMIE, F.L.S. Price, Rs. 7-8. (*Out of print.*)

Vol. II, No. III. Note on a Toxic Substance excreted by the Roots of Plants, by F. FLETCHER, M.A., B.Sc. Price, Re. 1-8.

Vol. II, No. IV. Studies in Root-Parasitism, III.—The Haustorium of *Olax scandens*, by C. A. BARBER, M.A., F.L.S. Price, Rs. 2-8.

Vol. II, No. V. Studies in Root-Parasitism, IV.—The Haustorium of *Cansjera Rheedii*, by C. A. BARBER, M.A., F.L.S. Price, Rs. 2-8. (*Out of print.*)

Vol. II, No. VI. Some Experiments in the Hybridising of Indian Cottons, by P. F. FYSON, B.A., F.L.S. Price, Re. 1-8. (*Out of print.*)

Vol. II, No. VII. The Varietal Characters of Indian Wheats, by ALBERT HOWARD, M.A., F.L.S.; and GABRIELLE L. C. HOWARD, M.A. Price, Re. 1. (*Out of print.*)

Vol. II, No. VIII. The Mulberry Disease caused by *Coryneum mori*, Nom., in Kashmir, with notes on other Mulberry Diseases, by E. J. BUTLER, M.B., F.L.S. Price, Re. 1-8. (*Out of print.*)

Vol. II, No. IX. The Wilt Disease of Pigeon-Pea and the Parasitism of *Neocosmospora vasinfecta*, Smith, by E. J. BUTLER, M.B., F.L.S. Price, Rs. 3.

Vol. III, No. I. Studies in Indian Tobaccos, No. 1.—The Types of *Nicotiana rustica*, L., Yellow Flowered Tobacco, by ALBERT HOWARD, M.A., A.R.C.S., F.L.S.; and GABRIELLE L. C. HOWARD, M.A. Price, Rs. 4.

Vol. III, No. II. Studies in Indian Tobaccos, No. 2.—The Types of *Nicotiana tabacum*, L., by ALBERT HOWARD, M.A., A.R.C.S., F.L.S.; and GABRIELLE L. C. HOWARD, M.A. Price, Rs. 9.

Vol. III, No. III. Studies in Indian Fibre Plants, No. 1.—On two Varieties of Sann, *Crotalaria juncea*, L., by ALBERT HOWARD, M.A., A.R.C.S., F.L.S.; and GABRIELLE L. C. HOWARD, M.A. Price, Re. 1.

Vol. III, No. IV. The Influence of the Environment on the Milling and Baking Qualities of Wheat in India, No. I.—The Experiments of 1907-08 and 1908-09, by ALBERT HOWARD, M.A., A.R.C.S., F.L.S.; H. M. LEAKE, M.A., F.L.S.; and GABRIELLE L. C. HOWARD, M.A. Price, Re. 1-8.

Vol. III, No. V. The Bud-Rot of Palms in India, by E. J. BUTLER, M.B., F.L.S. Price, Rs. 2.

Vol. III, No. VI. The Economic Significance of Natural Cross-fertilisation in India, by ALBERT HOWARD, M.A., A.R.C.S., F.L.S.; GABRIELLE L. C. HOWARD, M.A.; and ABDUR RAHMAN KHAN. Price, Rs. 4-8.

Vol. IV, No. I. Millets of the Genus *Setaria* in the Bombay Presidency and Sind, by G. A. GAMMIE, F.L.S. Price, Re. 1.

Vol. IV, No. II. Studies in Indian Fibre Plants, No. 2.—On some new Varieties of *Hibiscus cannabinus*, L., and *Hibiscus Sabdariffa*, L., by ALBERT HOWARD, M.A., A.R.C.S., F.L.S.; and GABRIELLE L. C. HOWARD, M.A. Price, Rs. 3.

Vol. IV, No. III. Notes on the Incidence and Effect of Sterility and of Cross-Fertilisation in the Indian Cottons, by H. M. LEAKE and RAM PRASAD. Price, Re. 1.

Vol. IV, No. IV. The Inheritance of Red Colour, and the Regularity of Self-fertilisation in *Corchorus capsularis*, L., the common Jute Plant, by R. S. FINLOW, B.Sc., F.C.S.; and I. H. BURKILL, M.A., F.L.S. Price, Re. 1.

Vol. IV, No. V. Observations on Certain Extra-Indian Asiatic Cottons, by H. M. LEAKE and RAM PRASAD. Price, Re. 1-8.

Vol. IV, No. VI. The Morphology and Parasitism of *Rhizoctonia*, by F. J. F. SHAW, B.Sc., A.R.C.S., F.L.S. Price, Rs. 2.

Vol. V, No. I. On the Inheritance of some Characters in Wheat. I, by A. HOWARD, M.A., A.R.C.S., F.L.S.; and GABRIELLE L. C. HOWARD, M.A. Price, Re. 1.

Vol. V, No. II. The Influence of the Environment on the Milling and Baking Qualities of Wheat in India, No. 2—The Experiments of 1909-10 and 1910-11, by A. HOWARD, M.A., A.R.C.S., F.L.S.; H. M. LEAKE, M.A., F.L.S.; and GABRIELLE L. C. HOWARD, M.A. Price, Re. 1.

Vol. V, No. III. The Varieties of Soy Beans found in Bengal, Bihar, and Orissa and their Commercial possibilities, by E. J. WOODHOUSE, M.A., F.L.S.; and C. S. TAYLOR, B.A. Price, Rs. 2.

Vol. V, No. IV. On *Phytophthora parasitica*, nov. spec. A new Disease of the Castor Oil Plant, by J. F. DASTUR, B.Sc. Price, Rs. 2.

Vol. V, No. V. Studies in *Peronosporaceæ*, by E. J. BUTLER, M.B., F.L.S.; and G. S. KULKARNI, L.Ag. Price, Rs. 2.

Vol. VI, No. I. Notes on Pollination and Cross-Fertilisation in the Common Rice Plant, *Oryza sativa*, Linn., by G. P. HECTOR, M.A., B.Sc. Price, Re. 1.

Vol. VI, No. II. A Sclerotial Disease of Rice, by F. J. F. SHAW, B.Sc., A.R.C.S., F.L.S. Price, Re. 1.

Vol. VI, No. III. Studies in Indian Tobaccos, No. 3.—The Inheritance of Characters in *Nicotiana tabacum*, L., by GABRIELLE L. C. HOWARD, M.A. Price, Rs. 3.

Vol. VI, No. IV. Studies in Indian Cottons, Part I—The Vegetative Characters, by H. M. LEAKE, M.A., F.L.S.; and RAM PRASAD. Price, Rs. 3-8.

Vol. VI, No. V. Red Rot of Sugarcane, by E. J. BUTLER, M.B., F.L.S.; and A. HAFIZ KHAN. Price, Re. 1.

Vol. VI, No. VI. Some New Sugarcane Diseases, by E. J. BUTLER, M.B., F.L.S.; and ABDUL HAFIZ KHAN. Price, Rs. 2.

Vol. VI, No. VII. Preliminary Note on the Classification of Rice in the Central Provinces, by R. J. D. GRAHAM, M.A., B.Sc. Price, Re. 1-8.

CHEMICAL SERIES.

Vol. I, No. I. The Composition of Indian Rain and Dew, by J. WALTER LEATHER, Ph.D., F.I.C., F.C.S. Price, Re. 1.

Vol. I, No. II. The Composition of the Oil-Seeds of India, by J. W. LEATHER, Ph.D., F.I.C., F.C.S. Price, Re. 1. (*Out of print.*)

Vol. I, No. III. The Pot Culture House at the Agricultural Research Institute, Pusa, by J. W. LEATHER, Ph.D., F.I.C., F.C.S. Price, Rs. 3.

Vol. I, No. IV. Experiments on the Availability of Phosphates and Potash in Soils, by J. W. LEATHER, Ph.D., F.I.C., F.C.S. Price, Re. 1-8.

Vol. I, No. V. The Construction of Drain Gauges at Pusa, by M. H. ARNOTT, M.INST.C.E., with a Preface by J. W. LEATHER, Ph.D., F.I.C. Price, Rs. 3. (*Out of print.*)

Vol. I, No. VI. The Loss of Water from Soil during Dry Weather, by J. WALTER LEATHER, Ph.D., F.I.C., F.C.S. Price, Rs. 2. (*Out of print.*)

Vol. I, No. VII. The System Water, Calcium Carbonate, Carbonic Acid, by J. WALTER LEATHER, Ph.D., F.I.C., F.C.S.; and JATINDRA NATH SEN, M.A., F.C.S. Price, Re. 1.

Vol. I, No. VIII. Water Requirements of Crops in India, by J. WALTER LEATHER, Ph.D., F.I.C., F.C.S. Price, Rs. 3.

Vol. I, No. IX. The Nature of the Colour of Black Cotton Soil, by H. E. ANNETT, B.Sc., F.C.S., M.S.E.A.C. Price, Re. 1.

Vol. I, No. X. Water Requirements of Crops in India—II, by J. WALTER LEATHER, Ph.D., F.I.C. Price, Rs. 2-8.

Vol. II, No. I. The Composition of the Milk of some Breeds of Indian Cows and Buffaloes and its Variations, Part I. The milk of some breeds of Indian Cows, by A. A. MEGGITT, B.Sc.; and H. H. MANN, D.Sc. Price, Re. 1-8.

Vol. II, No. II. Records of Drainage in India, by J. W. LEATHER, Ph.D., F.I.C. Price, Re. 1.

Vol. II, No. III. The *Rab* System of Rice Cultivation in Western India, by H. H. MANN, D.Sc.; N. V. JOSHI, B.A., B.Sc., L.Ag.; and N. V. KANITKAR, B.Ag. Price, Re. 1.

Vol. II, No. IV. The Composition of the Milk of some Breeds of Indian Cows and Buffaloes and its Variations, Part II. The milk of some breeds of Indian Buffaloes, by A. A. MEGGITT, B.Sc.; and H. H. MANN, D.Sc. Price, Re. 1-8.

Vol. II, No. V. A contribution to the Knowledge of the Black Cotton Soils of India, by W. H. HARRISON, M.Sc.; and M. R. RAMASWAMI SIVAN, B.A. Price, Re. 1.

Vol. II, No. VI. The Date-Sugar Industry in Bengal. An Investigation into its Chemistry and Agriculture, by H. E. ANNETT, B.Sc., F.C.S., M.S.E.A.C., assisted by G. K. LELE, L.Ag.; and BHAILAL M. AMIN, B.A. Price, Rs. 3.

Vol. III, No. I. Evaporation from a plain Water Surface, by J. WALTER LEATHER, Ph.D., F.I.C. Price, Re. 1.

CHEMICAL SERIES—*contd.*

Vol. III, No. II. Studies in the Chemistry and Physiology of the Leaves of the Betel-Vine (*Piper Betle*) and of the Commercial Bleaching of Betel-Vine Leaves, by H. H. MANN, D.Sc.; D. L. SAHASRABUDDHE, B.Sc., L.Ag.; and V. G. PATWARDHAN, B.Ag. Price, Re. 1-8.

Vol. III, No. III. The Gases of Swamp Rice Soils, their Composition and Relationship to the Crop, by W. H. HARRISON, M.Sc.; and P. A. SUBRAMANIA AIYER, B.A. Price, Re. 1-8.

Vol. III, No. IV. The Experimental Error in Sampling Sugarcane, by J. W. LEATHER, V.D., Ph.D., F.I.C. Price, Re. 1.

Vol. III, No. V. The Fractional Liquefaction of Rice Starch, by F. J. WARTH, M.Sc.; and D. B. DARABSETT, B.Sc. Price, Re. 1.

Vol. III, No. VI. The Yield and Composition of the Milk of the Montgomery Herd at Pusa and Errors in Milk Tests, by J. W. LEATHER, V.D., Ph.D., F.I.C.; and A. C. DOBBS. Price, Re. 1 or 1*s.* 6*d.*

Vol. III, No. VII. The System Potassium Nitrate, Sodium Chloride, Water, by J. W. LEATHER, V.D., Ph.D., F.I.C.; and JATINDRA NATH MUKERJEE, B.A., B.Sc. Price, Re. 1 or 1*s.* 6*d.*

Vol. III, No. VIII. The Systems—(A) Water, Magnesium Carbonate and Carbonic Acid, (B) Water, Calcium Carbonate, Magnesium Carbonate and Carbonic Acid, by J. W. LEATHER, V.D., Ph.D., F.I.C.; and JATINDRA NATH SEN, M.A., F.C.S. Price, Re. 1 or 1*s.* 6*d.*

Vol. III, No. IX. Studies of an Acid Soil in Assam, by A. A. MEGGITT, B.Sc., F.C.S. Price, Re. 1-8 or 2*s.* 6*d.*

ENTOMOLOGICAL SERIES.

Vol. I, No. I. The Bombay Locust—A report on the Investigations of 1903-04, by H. M. LEFROY, M.A., F.E.S., F.Z.S. Price, Rs. 2-8.

Vol. I, No. II. The more Important Insects injurious to Indian Agriculture, by H. M. LEFROY, M.A., F.E.S., F.Z.S. Price, Rs. 3. (*Out of print.*)

Vol. I, No. III. The Indian Surface Caterpillars of the Genus *Agrotis*, by H. M. LEFROY, M.A., F.E.S., F.Z.S.; and C. C. GHOSH, B.A. Price, Re. 1-8. (*Out of print.*)

Vol. I, No. IV. Individual and Seasonal Variations in *Helopeltis Theivora*, Waterhouse, with description of a new species of Helopeltis, by HAROLD H. MANN, D.Sc. Price, Re. 1-8.

Vol. I, No. V. The Coccidæ attacking the Tea Plant in India and Ceylon, by E. E. GREEN, F.E.S., F.L.S.; and HAROLD H. MANN, D.Sc. Price, Re. 1. (*Out of print.*)

Vol. I, No. VI. The Mustard Sawfly, by H. M. LEFROY, M.A., F.E.S., F.Z.S.; and C. C. GHOSH, B.A. Price, Re. 1. (*Out of print.*)

Vol. II, No. I. The Rice Bug, by H. M. LEFROY, M.A., F.E.S., F.Z.S. Price, Re. 1.

Vol. II, No. II. Remarks on Indian Scale Insects (*Coccidæ*) Part III, by E. E. GREEN, F.E.S., F.Z.S. Price, Re. 1-8.

Vol. II, No. III. The Red Cotton Bug, by H. M. LEFROY, M.A., F.E.S., F.Z.S. Price, Re. 1. (*Out of print.*)

Vol. II, No. IV. The Castor Semi-Looper, by H. M. LEFROY, M.A., F.E.S., F.Z.S. Price, Rs. 2.

Vol. II, No. V. The Tobacco Caterpillar, by H. M. LEFROY, M.A., F.E.S., F.Z.S. Price, Re. 1-8.

Vol. II, No. VI. The Cotton Leaf-Roller, by H. M. LEFROY, M.A., F.E.S., F.Z.S. Price, Re. 1-8. (*Out of print.*)

Vol. II, No. VII. Notes on Indian Scale Insects (*Coccidæ*), by H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S. Price, Re. 1-8.

Vol. II, No. VIII. Life-Histories of Indian Insects (*Coleoptera*—I), by H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S. Price, Rs. 2.

Vol. II, No. IX. Life-Histories of Indian Insects—II. Some Aquatic *Rhynchota* and *Coleoptera*, by D. NOWROJEE, B.A. Price, Re. 1-8.

Vol. II, No. X. Life-Histories of Indian Insects—III. The Rhinoceros Beetle (*Oryctes rhinoceros*) and the Red or Palm Weevil (*Rhynchophorus ferrugineus*), by C. C. GHOSH, B.A. Price, Rs. 2.

Vol. III. The Food of Birds in India, by C. W. MASON, M.S.E.A.C., edited by H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S. Price, Rs. 7-8.

Vol. IV, No. I. Eri Silk, by H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S.; and C. C. GHOSH, B.A. Price, Rs. 3.

Vol. IV, No. II. Tetriginæ (Acridiinæ) in the Agricultural Research Institute, Pusa, Bihar, with descriptions of new species, by Dr. J. L. HANCOCK, F.E.S. Price, Re. 1.

Vol. IV, No. III. The Big Brown Cricket (*Brachytrypes achatinus*, Stoll), by C. C. GHOSH, B.A. Price, Re. 1.

Vol. IV, No. IV. Life-Histories of Indian Insects—IV (*Hymenoptera*), by G. R. DUTT, B.A. Price, Rs. 2.

Vol. IV, No. V. Inquiry into the Insecticidal action of some Mineral and other Compounds on Caterpillars, by H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S., and R. S. FINLOW, B.Sc., F.C.S. Price, Re. 1-8.

Vol. IV, No. VI. The "*Psylla*" Disease of Indigo, by A. J. GROVE, M.Sc.; and C. C. GHOSH, B.A. Price, Re. 1-8 or 2*s.* 6*d.*

Vol. V, No. I. Life-Histories of Indian Insects—V. *Lepidoptera* (Butterflies), by C. C. GHOSH, B.A. Price, Rs. 2-8 or 3*s.* 9*d.*

BACTERIOLOGICAL SERIES.

Vol. I, No. I. Studies in Bacteriological Analysis of Indian Soils, No. 1, 1910-11, by C. M. HUTCHINSON, B.A. Price, Rs. 2-8.

Vol. I, No. II. Rangpur Tobacco Wilt, by C. M. HUTCHINSON, B.A. Price, Rs. 2.

VETERINARY SERIES.

Vol. I, No. I. Anaphylaxis in the Larger Animals, by Major J. D. E. HOLMES, M.A., D.Sc., M.R.C.V.S. Price, Rs. 2.

Vol. I, No. II. Salvarsan in the treatment of Surra in Horses, Dogs, and Rabbits, by Major J. D. E. HOLMES, M.A., D.Sc., M.R.C.V.S. Price, Re. 1-4.

Vol. I, No. III. Some more successful Experiments on the treatment of Surra in the Camel with recommendations for Systematic treatment, by A. S. LEESE, M.R.C.V.S. Price, Re. 1.

Vol. I, No. IV. On the Immune Bodies occurring in Anti-Rinderpest Serum, and on the Variations occurring in the Serum Proteins of Animals during Rinderpest, and during Immunization and Hyper-Immunization, by P. HARTLEY, D.Sc. Price, Rs. 2.

Vol. II, No. I. Some cases of Surra treated in the Field and in the Laboratory during the Autumn of 1911, by Major J. D. E. HOLMES, M.A., D.Sc., I.C.V.D. Price, Re. 1.

Vol. II, No. II. Rinderpest: Further Investigations on Questions connected with the Economical Production of Anti-serum, by Major J. D. E. HOLMES, M.A., D.Sc., I.C.V.D. Price, Re. 1.

Vol. II, No. III. The Curative Treatment of Hæmorrhagic Septicæmia in Cattle by the administration of Iodine, and other notes on Chemiotherapy in Rinderpest and Hæmorrhagic Septicæmia, by Major J. D. E. HOLMES, C.I.E., M.A., D.Sc., I.C.V.D. Price, Re. 1 or 1s. 6d.

Vol. II, No. IV. The Vitality of the Hæmorrhagic Septicæmia Organism outside the body, by Major J. D. E. HOLMES, C.I.E., M.A., D.Sc., I.C.V.D. Price, Re. 1 or 1s. 6d.

Vol. II, No. V. Bursati, by Major J. D. E. HOLMES, C.I.E., M.A., D.Sc., M.R.C.V.S. Price, Re. 1-8-0 or 2s. 3d.

Vol. II, No. VI. Experiments on the treatment of Surra in Camels, by H. E. CROSS, M.R.C.V.S., D.V.H., A.Sc. Price, Re. 1 or 1s. 6d.

Vol. II, No. VII. Anthrax—Some Experiments on the Immunising effect of the Simultaneous Injection of an Anthrax attenuated virus and an Anthrax Anti-serum by Major J. D. E. HOLMES, C.I.E., M.A., D.Sc., M.R.C.V.S. Price, Re. 1 or 1s. 6d.

BULLETINS ISSUED BY THE AGRICULTURAL RESEARCH INSTITUTE, PUSA.

No. 1. Notes on Cotton in Bihar in 1904, by H. M. LEFROY, M.A., F.E.S., F.Z.S. Price, As. 4 or 6d.

No. 2. An Outbreak of Cotton Pests in the Punjab, 1905, by H. M. LEFROY, M.A., F.E.S., F.Z.S. Price, As. 6 or 7d.

No. 3. The Extension of Jute Cultivation in India, by R. S. FINLOW, B.Sc., F.C.S. Price, As. 12 or 1s. 2d. (*Out of print.*)

No. 4. First Report on the Fruit Experiments at Pusa, by A. HOWARD, M.A., A.R.C.S., F.C.S. Price, As. 6 or 6d.

No. 5. Report on Trials of the South African Locust Fungus in India, by E. J. BUTLER, M.B., F.L.S.; and H. M. LEFROY, M.A., F.E.S., F.Z.S. Price, As. 2 or 3d.

No. 6. The Ticks Infesting Domesticated Animals in India, by C. WARBURTON, M.A. Price, As. 4 or 6d.

No. 7. A Preliminary Account of the Biting Flies of India, by H. M. LEFROY, M.A., F.E.S., F.Z.S. Price, Re. 1 or 1s. 6d. (*Out of print.*)

No. 8. Official and Recommended Methods for use in Chemical Laboratories of the Departments of Agriculture in India, by J. WALTER LEATHER, Ph.D., F.I.C., F.C.S. Price, As. 4 or 6d.

No. 9. Report on Coconut Palm Disease in Travancore, by E. J. BUTLER, M.B., F.L.S. Price, As. 6 or 6d.

No. 10. Treatment and Observation of Crop Pests on the Pusa Farm, by H. M. LEFROY, M.A., F.E.S., F.Z.S.; and C. S. MISRA, B.A. Price, As. 6 or 7d.

No. 11. On Flax Dodder, by A. HOWARD, M.A., A.R.C.S., F.C.S. F.L.S. Price, As. 4 or 6d.

No. 12. The Making and Care of Lawns in India, by A. HOWARD, M.A., A.R.C.S., F.C.S. F.L.S. Price, As. 4 or 6d. (*Out of print.*)

No. 13. Sugarcane at the Partabgarh Experiment Station, by G. CLARKE, F.I.C.; and Khan Bahadur S. M. HADI, M.R.A.C., M.R.A.S. Price, As. 6 or 6d.

No. 14. The Milling and Baking Qualities of Indian Wheats, by A. HOWARD, M.A., A.R.C.S., F.C.S. F.L.S.; and GABRIELLE L. C. HOWARD, M.A. Price, As. 4 or 6d.

No. 15. Note on the Extension of Cultivation of Fibre Plants in India. Price, As. 6 or 8d.

No. 16. Second Report on the Fruit Experiments at Pusa, by A. HOWARD, M.A., A.R.C.S., F.L.S. Price, As. 6 or 8d.

BULLETINS ISSUED BY THE AGRICULTURAL RESEARCH INSTITUTE, PUSA—*concld.*

No. 17. The Milling and Baking Qualities of Indian Wheats, No. 2. Some new Pusa Selections tested in 1909, by A. HOWARD, M.A., A.R.C.S., F.L.S.; and GABRIELLE L. C. HOWARD, M.A. Price, As. 6 or 8*d.*

No. 18. Report on the Outbreak of Blister-Blight on Tea in the Darjeeling District in 1908-09, by W. MCRAE, M.A., B.SC. Price, Re. 1 or 1*s.* 6*d.*

No. 19. List of Names used in India for Common Insects, compiled in the Laboratory of the Imperial Entomologist, Pusa. Price, As. 12 or 1*s.* 2*d.*

No. 20. Memorandum on Indian Wheat for the British Market, by Sir JAMES WILSON, K.C.S.I. Price, As. 4 or 6*d.*

No. 21. Memorandum regarding Leading Eucalypts suitable for India, by F. BOOTH-TUCKER. Price, As. 4 or 5*d.* (*Out of print.*)

No. 22. The Milling and Baking Qualities of Indian Wheats, No. 3. Some New Pusa Hybrids tested in 1910, by A. HOWARD, M.A., A.R.C.S., F.L.S.; and GABRIELLE L. C. HOWARD, M.A. Price, As. 7 or 8*d.*

No. 23. Insecticides—Mixtures and Recipes for use against Insects in the Field, the Orchard, the Garden, and the House, by H. M. LEFROY, M.A., F.E.S., F.Z.S. Second edition, revised with many additions by T. BAINBRIGGE FLETCHER, R.N., F.E.S., F.Z.S. Price, As. 12 or 1*s.* 2*d.*

No. 24. The Indian Saltpetre Industry, by J. W. LEATHER, Ph.D., F.I.C., F.C.S.; and J. N. MUKHERJI, B.A., B.SC. Price, As. 8 or 9*d.*

No. 25. Report on the Flax Experiments conducted at Dooriah during the year 1910-11, by E. M. VANDEKERKHOVE. Price, As. 6 or 7*d.*

No. 26. Note on the present position of Cotton Investigation in India, by BERNARD COVENTRY, C.I.E. Price, As. 2 or 3*d.*

No. 27. Experiments on the Cultivation of Sugarcane at the Partabgarh Experiment Station, 1909-11, by G. CLARKE, F.I.C.; H. E. ANNETT, B.SC.; and SYED ZAMIN HUSAIN, B.A. Assisted by S. C. BANERJEE and NAIB HUSSAIN. Price, As. 5 or 6*d.*

No. 28. The Cultivation of Lac in the Plains of India, by C. S. MISRA, B.A. Price, As. 8 or 9*d.* (2nd edition, revised.)

No. 29. Directions for the Cultivation of Eri Silk. Revised edition. Price, As. 3 or 4*d.*

No. 30. Report on the Flax Experiments conducted at Dooriah during the year 1911-12, by E. M. VANDEKERKHOVE. Price, As. 1-6 or 2*d.*

No. 31. Wheat Experiments on the Botanical Area, Cawnpur, and their bearing on Wheat Cultivation in the United Provinces, by H. MARTIN LEAKE, M.A.; and RAM PRASAD. Price, As. 3 or 4*d.*

No. 32. A Note on some Interesting Results following the Internal Administration of Arsenic in Canker and other Diseases of the Foot in Horses, by Major J. D. E. HOLMES, M.A., D.SC., M.R.C.V.S. Price, As. 2 or 3*d.*

No. 33. Some Aspects of the Agricultural Development of Bihar, by A. HOWARD, M.A., A.R.C.S., F.L.S. Price, As. 4 or 5*d.*

No. 34. Diseases of Rice, by E. J. BUTLER, M.B., F.L.S. Price, As. 8 or 9*d.*

No. 35. Report on the Flax Experiments conducted at Dooriah during the year 1912-13, by E. M. VANDEKERKHOVE. Price, As. 3 or 4*d.*

No. 36. Note on the M'Fadyean Staining reaction for Anthrax Bacilli, by Major J. D. E. HOLMES, M.A., D.SC., M.R.C.V.S. Price, As. 4 or 5*d.*

No. 37. Notes on Experiments with Sugarcane at Sabour, by C. SOMERS TAYLOR, B.A. Price, As. 2 or 3*d.*

No. 38. Disintegration of Rice Grains by means of Alkali, by F. J. WARTH, M.SC.; and D. B. DARABSETT, B.SC. Price, As. 6 or 7*d.*

No. 39. Instructions for rearing Mulberry Silk-worms, by M. N. DE, M.S.A. Price, As. 4 or 5*d.*

No. 40. Green Manuring Experiment, 1912-13, by C. M. HUTCHINSON, M.A.E.B.; and S. MILLIGAN, M.A., B.SC. Price, As. 4 or 5*d.*

No. 41. The use of Sweet Jowar (Sorghum sp.) as a source of Commercial Sugar or as Fodder and the variation in Composition of the crop during growth by H. E. ANNETT, B.SC., F.I.C., F.C.S., M.S.E.A.C. Price As. 2 or 3*d.*

No. 42. Notes on Cane Crushing in the United Provinces, by G. CLARKE, F.I.C., NAIB HUSSAIN, and S. C. BANERJEE. Assisted by LAKSHMI SHANKER. Price, As. 2 or 3*d.*

No. 43. A Note on the Effect of Heat on the Rinderpest Immune Bodies, by Major J. D. E. HOLMES, C.I.E., M.A., D.SC., M.R.C.V.S. Price, As. 2 or 3*d.*

No. 44. How to Improve Silk-Reeling in Bengal, by M. N. DE, M.S.A. (*In the press.*)

No. 45. The Acid Secretion of the Gram Plant, by D. L. SAHASRABUDDHE, B.SC., L.AG. (*In the press.*)

BOOKS.

"Indian Insect Pests," by H. M. LEFROY, M.A., F.E.S., F.Z.S. Price, Re. 1-8. (*Out of print.*)

"Indian Insect Life," by H. M. LEFROY, M.A., F.E.S., F.Z.S.; and F. M. HOWLETT, B.A. 786 pp. Price, Rs. 20 or 30*s.*

"Wheat in India," by A. HOWARD, M.A., A.R.C.S., F.L.S.; and GABRIELLE L. C. HOWARD, M.A. 288 pp. Price, Rs. 5 or 7*s.* 6*d.*

"A description of the Imperial Bacteriological Laboratory, Muktesar; its work and products," by Major J. D. E. HOLMES, M.A., D.SC., M.R.C.V.S. Price, As. 8 or 9*d.*